

**PLUG WINDOWS 10
PRIVACY LEAKS**

**LOCK IT DOWN WITH
OUR STEP-BY-STEP
HOW-TO GUIDE**

Oct 2015
Issue 420

EXPERT

GUIDE TO TODAY'S TECH

intel

APC'S EXCLUSIVE 17-PAGE

SKYLAKE MEGAGUIDE

LABS BENCHMARKED:
BLAZING INTEL CPUs &
Z170 MOTHERBOARDS

DDR4 IS HERE!

NINE NEW KITS ON
TEST, STARTING
FROM JUST \$85!

THE TRUTH REVEALED

TECH MYTHS BUSTED!

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optimise your SSD,
improve clipboard
management + more!

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for full details

TREMENDOUS TIPS & TWEAKS

- PC overclocking masterclass
- Make music with Arduino and Pi
- Linux networking tools explained

WINDOWS 10 & GAMING

Under-the-hood changes and DirectX12: is this the best OS yet for gamers?



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Email: apcmag@futurenet.com
Web: www.apcmag.com

EDITORIAL

Editor-in-Chief Dan Gardiner
Managing Editor Melanie Pike
Journalist Joel Burgess
Journalist Stephen Lambrechts

ART/PRODUCTION

Creative Director Troy Coleman
Senior Designer Nykke Coleman
Designer Sharnee Brisbane

CONTRIBUTORS

Matt Bolton, J.R. Bookwalter, Helen Bradley, Ben Griffin,
Daniel Grilopoulos, Lindsay Handmer, Phil Iwaniuk, Jeremy
Laird, Rod Lawton, Daniella Lucas, Les Pounder, Matthew
JC Powell, Matthew Sakuraoka-Gilman, Shashank Sharma,
Zak Storey, Nathan Taylor, Mihalis Tsoukalos, Louis Villazon,
Darren Yates

SENIOR MANAGEMENT

Chief Operating Officer Neville Daniels

COMMERCIAL

Sales Director Paul Marttila
paul.marttila@futurenet.com

Senior Sales Manager Jairo Manzoupo
jairo.manzoupo@futurenet.com

ABOUT THE MAGAZINE

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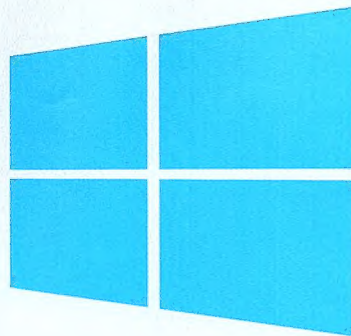
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Windows 10: great, but less relevant than ever

APC's editor reflects on our changing attitude to operating systems.

So, Windows 10's rolled out relatively successfully – most APC readers seem to be enjoying it at the very least (see page 14 for some of their responses) – and I've also got to say that, barring the odd app that doesn't co-operate nicely with Windows 10's new interface designs (meaning the heading text in boxes can get a bit clipped), I've found it fairly pleasant to work with and far more intuitive than its forebear.

But at the same time, I've also realised that I don't think about operating systems the same way that I used to. While I grew up using multiple OSs (the C64's command-line based Commodore BASIC 2.0, the Amiga 500's AmigaOS, and MS-DOS were what I cut my teeth on), since the mid 1990s I've been increasingly using Windows machines, running every iteration of the OS from 1993's Windows 3.1 to Windows 8.1 and now Windows 10.

However, the amount of time I spend with Windows has diminished drastically and the dominance of smartphones, in particular, has really opened up the whole OS scene – not just on the phones themselves, but on other devices too.

Macs are more popular than ever and Chromebooks are likewise seeing rising popularity in certain sectors – education, in particular. Even Linux is far less daunting than it used to be. I recently experimented with building a media PC using a NUC running Ubuntu and found it a fairly painless experience. Ubuntu is, admittedly, still reliant on users being happy to Google any problems

they have in a fairly logical fashion (and occasionally punch in some command-line fixes), but most of the issues you'll face are going to be at the time of setup or when installing new devices. Once you're actually running, it's fairly fuss-free, however. Its major shortcoming is (as its always been) a lack of drivers for hardware devices – though this has improved markedly, and the community seems to be pretty good at building its own where industry support still lags. Ubuntu even has a robust integrated app store and automatically updates any apps installed from there too, just like iOS and Android. In fact, Ubuntu is functional enough that I dare say I'd be tempted to use it as my day to day OS if it were for a few holdout work-related apps that keep me largely bound to Windows and Mac OS X.

So while Windows 10 seems to be a solid improvement over its predecessor – not that that was a hard thing to achieve – more generally speaking, Windows is arguably also the least-relevant it's been in almost 20 years.

If you've moved on from Windows, give us a shout about why you left and where you ended up. ■



DAN GARDINER
EDITOR-IN-CHIEF
dan.gardiner@futurenet.com

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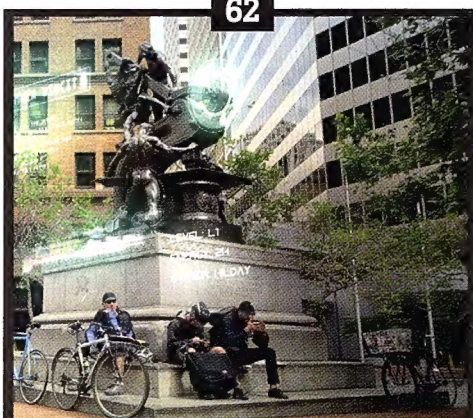
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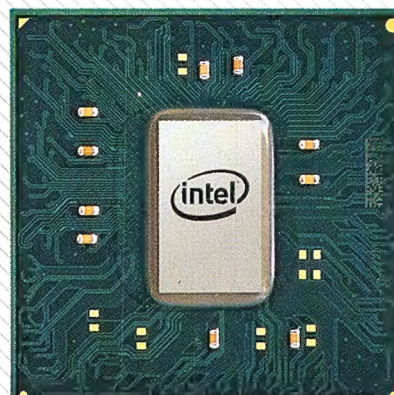
"So, if you're buying or building a new desktop, the 'tock' cycle makes more sense – it's the more mature tech and delivers extra speed." Tech Myths Busted. p36



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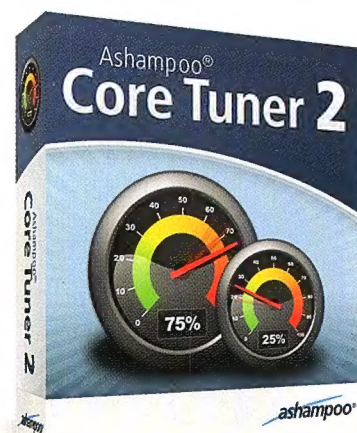
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- 5 Useful Productivity Tool

Find your disc inside on page 83. (Australian edition only.)





Windows RT devices to get a Windows 10 refresh

Don't throw your old Surface out yet.

Since it was first announced that Surface Pro owners would be getting a free upgrade from Windows 8.1 to Windows 10, owners of Windows RT tablets such as the Surface 1 and Surface 2 have wondered whether they'd be getting a similar kind of deal. The answer: kind of, but not really.

Windows 8.1 RT Update 3 will be released in September, and while it isn't quite the upgrade Windows RT users have been hoping for, it will provide an improved Start menu and lock screen.

The website WinBeta has reported that the code in this new Start menu will be different to the code found in the Windows 10 Start menu, and will instead be based on an earlier version

of the code from Windows 10 Technical Previews.

Unfortunately, Windows RT users will never get a proper version of Windows 10 on their tablets, as RT devices are unable to run applications that are built for the Universal Windows Platform (doesn't sound very universal, does it?).

Stephen Lambrechts

DRM kills the video-playing star

The promising Matchstick HDMI PC runs out of fuel, as DRM negotiations kick this Kickstarter to the curb.

During its funding run on Kickstarter, Matchstick was a resounding success. With over 17,000 backers, the promised product was a mini-HDMI dongle that would run a Firefox OS directly through the TV. The project managed to garner four times the amount of funding it needed for the campaign and with Mozilla openly backing the project, its success seemed fairly assured. Since its campaign, however, the Matchstick team have been struggling to negotiate the tricky task of getting digital rights management — which safeguards apps and content from unauthorised syndication — working with Matchstick's OS. Initially, the Firefox-based OS was intended to be open source, but Matchstick realised that a number of popular streaming services including Netflix require DRM and it made the decision to include DRM in February. In August, Matchstick announced that it had no reliable bearing on how long it'll take to complete DRM development — and that it doesn't want to put backers through a series of delays in order to get there. In a message to contributors through the Kickstarter campaign page (tinyurl.com/apc420match), Matchstick stated that it would refund 100% of backers by the end of September, despite the fact that many are actually calling for Matchstick to ship without DRM, as per the original. Joel Burgess





Ashley Madison leak was an inside job

Lone Avid Life Media employee responsible for stolen database?

A massive leak of customer data from the notorious adultery-based dating site Ashley Madison has sent shockwaves across the internet since mid July, with the identities of all its philandering users revealed for the world to see.

Though originally blamed on hackers, it's now been revealed that the leak was likely the work of a lone employee – possibly a female – working from within and exposing a massive vulnerability in the site's security – at least if you believe security pioneer John McAfee.

The manifesto that was posted with the stolen data is the basis for McAfee's

conclusion, stating that he's "practiced social engineering since the word was first invented" and that he can "very quickly identify gender if given enough emotionally charged words from an individual."

McAfee also stated that "from the data that was released, it was clear that the perpetrator had intimate knowledge of the technology stack of the company," further stating that "hackers rarely have full knowledge of the technology stack of a target."

Stephen Lambrechts

MIT quadruples battery lifespan

Lithium ion batteries are about to live four times longer.

Forgetfulness is generally seen as a bad thing, but for a few researchers at MIT, it was the key to one of the year's biggest breakthroughs in lithium ion battery technology. Attempting to find a way around the limited life cycle of expanding and contracting graphite anodes in current li-ion batteries, the team were researching the use of aluminum electrodes dunked in a sulphuric acid and titanium oxysulphate solution. The researchers accidentally left the electrodes in the solution for several hours and created a battery that has up to four times the battery 500-charge lifespan of current batteries. JB

eSports to implement drug testing

ESL takes steps to prohibit performance enhancing drugs.

The Electronic Sports League announced in July that it would begin randomly drug-testing players in video game tournaments, following a confession from a *Counter Strike: Global Offensive* player concerning the use of prescription ADHD medication to increase concentration in professional tournaments. The ESL intends to work with the World Anti-Doping organisation to create and enforce fair international drug rules for the ESL One Cologne tournament in August. JB

Ransomware rising

CryptoLocker taking Australians' files hostage.

The number of Australians reporting that their computer has been attacked by 'ransomware' has risen dramatically, with the most recent version of the CryptoLocker virus taking advantage of the arrival of Windows 10 in order to infect more users. CryptoLocker is an encryption virus which takes personal computer files hostage by encrypting them and then demanding the computer's owner pay a ransom in exchange for their decryption. In an attempt to combat this malicious virus, which is said to be one of the worst in existence, Australians have turned to shady hackers, who are charging thousands of dollars (in the form of Bitcoin, of course) to supposedly retrieve the affected files, however, many top IT people believe CryptoLocker to be unbreakable. Recent attacks have come via a legitimate looking email that claims to contain a Windows 10 installer in a zip file. Stephen Lambrechts

Sydney reporter publishes year's worth of metadata

Reveals that 2,500 meta-police have access to your every move.

In March, the Australian parliament passed a bill that will force ISPs to keep all of their users metadata for a minimum term of 2 years, on the off chance authorities want to look at it. The move was a controversial decision, one that detractors say puts the privacy of the Australian public at risk to provide an arguably dubious resource for tracking legitimate criminals. In August, Sydney based reporter Will Ockenden published a year's worth of his metadata online in order to demonstrate exactly what that stored metadata contains. That includes a running tab of your exact location every 20 minutes of every day, with a summarised report of the raw data compiled by the ABC

(tinyurl.com/APC420-Mdata) also showing the time, contact info and duration of every incoming and outgoing call made. ISPs will also store a number of things that Ockenden didn't divulge, including the time, contacts and file size of exchanged emails and similar information about your internet habits. The law restricts access to the metadata to 2,500 authorised individuals spread across 22 government agencies, (which went some way to quell concerns around the legitimacy of previously authorised bodies like the RSPCA and local councils), but the data will almost certainly be a desirable target for hackers.

Joel Burgess



1,391

THE NUMBER OF TAKEDOWN REQUESTS LODGED AGAINST PERISCOPE.

Livestreaming app Periscope got off to a strong start following its launch in March, but it's been accused by HBO of inciting "mass copyright infringement" when the service was used as an unauthorised free source to watch the Mayweather and Pacquiao fight in May. Twitter, the parent company of Periscope, recently released a transparency report that suggested that the livestreaming app had complied with 71% of the 1,391 takedown requests it received between April and July.

83%

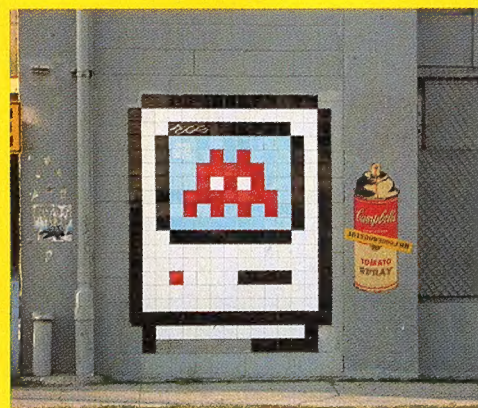
THE PROPORTION OF AUSSIE GAMERS THAT PLAY ON PC.

PC gaming has had a massive resurgence in Australia over the past couple of years. In 2013 the Digital Australia Report noted that 53% of gamers had a PC that was used for gaming — a figure that has skyrocketed to 83% since then. Interestingly, the PC gaming boom hasn't come at the cost of any console presence, which remained at a constant 63% between 2013 and 2015. The only decline in gaming platform share over the period was dedicated gaming share handhelds, which shrank from 22% to 15%.

205 days

THE AVERAGE LENGTH OF TIME BEFORE A BUSINESS DISCOVERS A DATA BREACH.

Although the better part of a year seems like an absurdly long time for a company to be unaware of a hack, what's even more surprising is that 69% of all data breaches actually come to the attention of the businesses involved by an independent third party, like a media organisation or a security firm. These figures, which come from the US cybersecurity firm Mandiant's 2015 Security Report, suggest that businesses were actually 10% faster at realising breaches in 2014 than in the previous year. At least they're improving?



#1

SPACE INVADERS IS THE TOP GROSSING GAME OF ALL TIME WITH \$13.9B IN REVENUE.

It might seem surprising, but arcade games take out the top three slots when the total revenues of games are ranked and then adjusted for inflation. *Space Invaders*, *Pac Man* and *Street Fighter* blow everything from *World of Warcraft* to *GTAV* out of the water, and the fact that you can still find an active machine at the back of the odd pub is a sentiment to just how prevalent the games were in their day. And when you think about it, having to pay a dollar for every five or so minutes of gameplay goes some way to explaining *Space Invaders'* exorbitant US\$13.9B of adjusted total revenue.



\$10K+

THE ESTIMATED COST OF A 2.5 INCH 16TB SAMSUNG SSD.

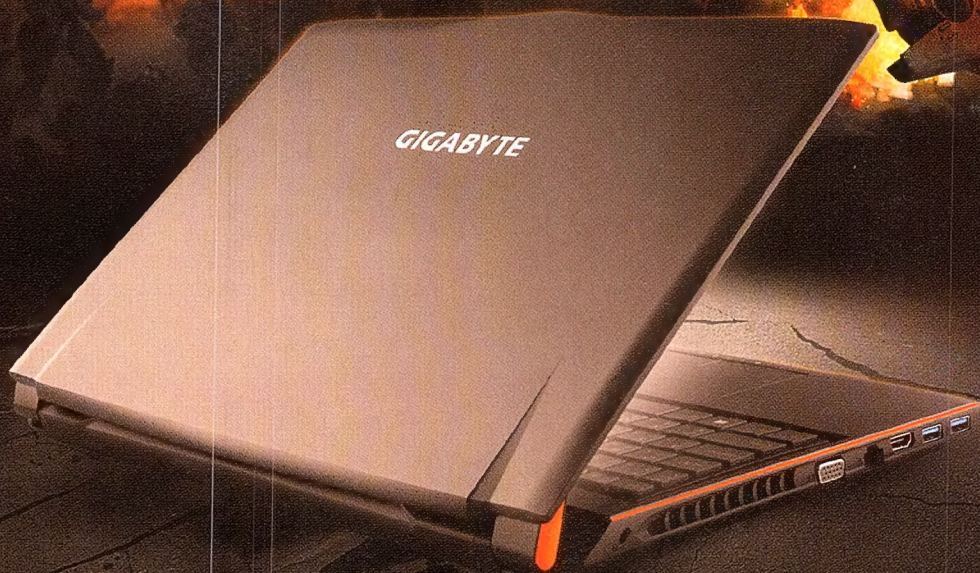
At the Californian Flash Memory summit in August, Samsung unveiled the world's largest single solid-state hard drive with a staggering capacity of 16TB. While 8TB mechanical drives are currently available from WD and Seagate, Samsung's aiming to double that with flash memory. The new SSD is the result of Samsung's development of 256-Gigabit 3D vertical NAND flash memory and though there is no word on pricing yet it's estimated to be in excess of \$10,000.

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P55 GTX 970M / 965M

15.6" GAMING LAPTOP

5th Gen Intel® Core™ i7 Processor



XSplit Gamecaster
Streaming Software



Dual Storage: Up to 512GB
mSATA SSD + 2TB HDD
(optional)



Full HD IPS Wide View
Matte Display
(optional)



Dolby® Digital Plus™
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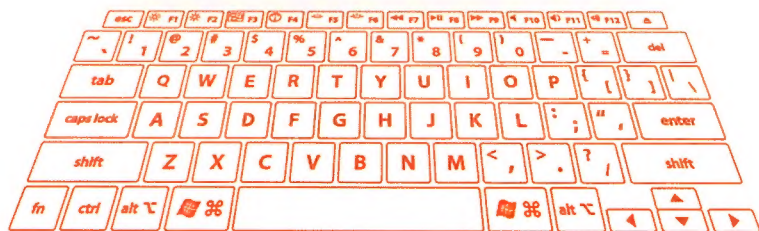
technotes

» GEAR WE WANT

REMIXED MINI

1GB RAM, US\$30; 2GB RAM, US\$50 | JIDE.COM

This tiny computer is no bigger than your average portable hard drive and its operating system is custom-built from a reengineered version of Android Lollipop, called Remix OS. The new Remix Mini has Ethernet, HDMI, headphone and USB ports and both Wi-Fi and Bluetooth connectivity. All this is run via one of Allwinner Technologies recently-released 64-bit, quad-core 2GHz Cortex CPUs and comes in two versions: 1GB of RAM and 8GB of storage, or 2GB RAM and 16GB of storage. But the micro-PC hardware is not really what makes this Kickstarter unique – it's the software. The Remix OS combines the app software underpinnings of Android with the screen layout, task bar and mouse and keyboard utilities of a regular PC.



VIRTUAL KEYBOARD

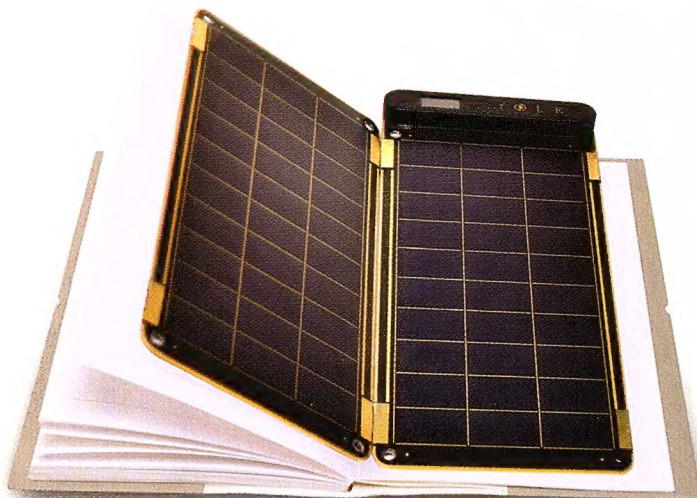
US\$90 | TINYURL.COM/APC420-LKEY

Typing anything more than a text on your smartphone or tablet is tedious and though there are a number of Bluetooth mobile keyboards available, for most of us lugging around a portable keyboard seems like overkill for the few times we really need one. The Virtual Keyboard is a little cube featuring a laser projector that displays a keyboard onto any flat surface, with a receiver built into the base of the device which collects the light reflected from your fingers when you type. This little cube is easy to carry around and has an average 2 hour in-use battery life, making the Virtual Keyboard a handy smartphone or tablet accessory.

YOLK SOLAR PAPER

FROM US\$120 | YOLKSTATION.COM

This efficient, expandable solar-charging unit for USB-powered devices looks ideal for camping and hiking trips – or just to have in your car for emergencies. Its panels are ultra-thin (hence the “paper” name), so it folds away to almost nothing, and weighs little. With two panels, in strong sunlight it can produce 5W of power – enough to charge an iPhone at the same speed as a wall socket. The brilliant part is that you can add more panels with just a simple magnetic connector, meaning you get more power on cloudy days, or can even charge an iPad.





SPHERICAM 2

US\$1,499 | SPHERICAM.COM

In its camouflaged tones of green or black, the SpheroCam 2 looks like something unearthed at a secret military base. But fear not, it's actually a mountable 4K, 60-frames-per-second, 360-degree video camera. Available in December 2015, it has a big resolution in a tiny camera. Recording 4K video is blowing up in a big way, and this looks like a great way to do it. Its six integrated cameras enable full 360-degree capture — perfect for creating VR projects — while its manufacturer claims it's the only camera of its kind with a 'global shutter' that captures every pixel from each camera simultaneously. Action!

LUMOS HELMET

\$TBC | WWW.LUMOSHELMET.CO

We generally come down firmly in support of tech that keeps people alive here at APC, so this smart cycling helmet from Lumos looks great. It's lined with LED lights to help keep the wearer visible at night, but it does more than that. When you brake, a built-in accelerometer detects the change in motion, and turns all the rear lights to a solid red, so cars behind can easily see what's happening. But it also has a remote control that sits on your handlebars to activate big, clear turn indicators on the rear and front. It looks likely to cost about US\$180 upon release, and should arrive in mid 2016.



GLOCAL ME

€120 PLUS DATA | GLOCALME.COM

If you do a bit of travelling, you'll know that when you need directions to a destination or have to check an itinerary online, not having internet is a problem. But local SIMs are a hassle and roaming charges are expensive. Glocal Me is a portable 3G Wi-Fi hotspot dongle with a built-in SIM card that works in over 100 countries worldwide. By registering an online account, you have access to reasonably priced data in whatever country you want from the second you get off the plane. The 6000mAh battery allows you to use the device for up to 10 hours or alternatively, re-charge your smartphone on the go. With €5 netting you at least 100MB of data, Glocal Me is as easy as roaming with the data prices of a local SIM.

technotes

HOW IT'S DONE



Apple Mac Mini

Just how much does Apple cram into its latest small form factor machine?

BACKGROUND

The Mac Mini is just a tiny PC that happens to ship with a proprietary non-Windows OS. And say what you want about Apple, but it does have an annoying habit of engineering its hardware seriously well. What we have, then, is an interesting look at something akin to a money-no-object engineering job on a small form factor PC. Dig in!

MAJOR TECH SPECS

- 1.4GHz dual-core Intel Core i5 (turbo boost up to 2.7GHz) with 3MB L3 cache
- 4GB of 1600MHz LPDDR3 memory
- 500GB hard drive
- Intel HD Graphics 5000
- 802.11ac Wi-Fi and Bluetooth 4.0

KEY FINDINGS

- The backside is almost identical to the previous iteration. The only change is the omission of a FireWire port in favour of an extra Thunderbolt 2 port. Gone are the

handy thumb indents and indicators. The twist-off bottom cover is also a goner, replaced by a pop-off cover that reveals a new metal door where there was once handy access to the RAM and fan.

- The door is secured with three TR6 Torx Security screws. Really? Rude. They're the smallest we've ever seen.
- Finally inside, we pop out the fan and its fancy Advanced Hydraulic Bearing. The AirPort card is dispatched next, after removing a screw and disconnecting two antennas.
- Using our hand-powered Mac Mini logic board removal tool, we remove the board. Past Minis have had two SATA ports, allowing for an extra hard drive. This year we only get one.
- On one side we find 4GB of Samsung LPDDR3 DRAM. But it's soldered to the logic board. If you want to upgrade the RAM, you must do so at time of purchase. Then there's the Cirrus Logic 4208-CRZ Audio Codec, the Intel DSL5520 Thunderbolt 2

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

Controller, and the Broadcom Ethernet PCIe Controller with SD3.0 Card Reader and ASF 2.0. We also discover the Intel Core i5-4260U processor with Intel HD Graphics 5000 (again, soldered), along with the Macronix BIOS chip.

- All that's left is the neatly packaged 85W power supply (unchanged since 2011) and the hard drive caddy with its conventional 2.5-inch magnetic drive.
- Repairability Score: 6 out of 10 (10 is easiest to repair). That's down two from the previous Mini. Sure, with the proper tools, disassembly is straightforward. But TR6 Torx Security screws are intended to lock you out and make it hard to clean the fan or replace the hard drive. Plus the CPU and RAM are soldered to the logic board and not user-upgradeable. ■

GIGABYTE™



WORLD OF TANKS

ROLL OUT

BATTLE READY

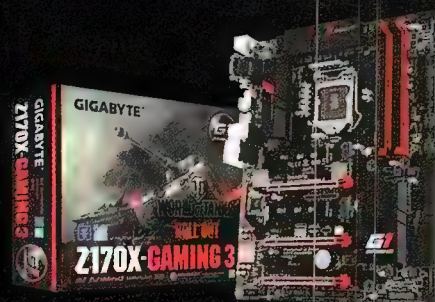


GIGABYTE Gaming Series Motherboard



WARGAMING.NET
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Windows 10 reader reactions

Last month, we asked APC readers what they thought of the Windows 10 upgrade and received an overwhelming number of responses. Most were positive, although the install process didn't always go smoothly. Here's what you had to say.

After reading your articles about Windows 10 I was looking forward to using it. But I found the hard part is installing the blasted thing! To be on the safe side I cloned my main drive to a spare, I passed the compatibility checks, then downloaded 10 using my upgrade notification. It wouldn't install. After several failed attempts and contacting Microsoft who advised downloading the ISO file to DVD it will still not install.

I notified Microsoft about error code 1900121-20017 but have not yet received a reply. I have tried all the fixes I could find, some rather bizarre, but my computer resolutely remains on Windows 7.

Surely if one designed a computer program to return error codes for when something goes amiss, then one would presumably know what the error code is trying to tell you?

Like we always used to say. "Ah, Windows, just another pain in the glass." I may be 74 but enjoy my computing as much as ever, and now I feel so much better after my little rant.
Mike Iverson

Like you I updated to Windows 10 on the launch day. I had issues with the installation files that were downloading in the background. Ended up deleting them and using the ISO tool provided by Microsoft. It was a smooth process from there. My N54L microserver however had issues. Kept getting the "something has happened" error. Ended up doing the same ISO trick, but instead of downloading the files to the microserver I used a USB which seemed to fix the error.

I've had a few updates since launch and overall I'm happy, but I'm definitely looking forward to more updates to fix these annoying slow downs. I really like where Microsoft is heading, but

I'm recommending anyone who has not upgraded yet to wait a couple more months so some bugs are ironed out.
Paul D

I've put five PCs through the upgrade process, with few glitches. Apart from a few minor niggles, I am having no trouble adapting to 10, and so far everything else seems to work.

David Morton

My feedback on Windows 10 is quite mixed. My HP Folio 13 laptop refuses to upgrade. It will download and prepare for install, but when it gets to the updating Windows screen it gets to 85% hangs and then after an hour or so boots back into 7. I tried the advice in last month's editorial, also with no success. It hangs at the first reboot and then goes back to 7. I'm glad I have large download limits. I have tried this at least 6 times with a full download each time!

My other machine is a home built desktop running 8.1 and it upgraded with no problems. With limited time to explore 10 as yet, it looks very nice.
John

My own upgrade experience went quiet well – lucky me. I chose the ISO route to upgrade one of my 8.1 systems. But that's where the problem free upgrades stop. As a computer repairer my phone has begun to ring constantly, thanks Microsoft!

I went to a workshop to have a further look at 10, it took twenty minutes of black screen to load, I assume this was an update? A little info, a bit of code, "sorry we are updating your Windows right now", would have been nice. My clients don't know what's going on, they think their system is broken. I had advised most to upgrade to 8.1 once it was ready to roll, mainly because of the

7 update problems and huge downloads. This is taking so much office time for them. If 10 is to follow suit lots of my folks will move over to Macs in time as Apple knows how to deal with update issues.

Dave Pearcey

I have installed Windows 10 on two desktops and three laptops so far. My desktop (8.1) upgrade went smoothly, as did all the others, until afterwards when I found a few issues.

I didn't like Edge at first as it was behaving strangely then stopped searching all together. I made Google my default start-up page and my default search engine and it works well now.

Other than that all went well until Microsoft Word would not open any documents. I don't know if it was the fault of Windows 10, but with a bit of registry tweaking all is fine. All thanks to the many blogs and how to fix it videos found on line.

The other issue with my desktop is that my VPN to the office is no longer compatible. I have not found an answer to that yet but I am sure Cisco will fix it. I can use Team Viewer in the meantime.

Vince Turco

My upgrade was as per your experience – I have an HP Pavilion 500-125A with Windows 8.1 Home Edition. After downloading the 10 upgrade I rebooted my PC and got an error message. It said it couldn't proceed and then undid the upgrade and rebooted back to 8.1. The error provided was 0x80070057. Everything I tried failed until I followed the upgrade error postings. Following the steps solved the problem and installed Windows 10. The path I followed was tinyurl.com/ohyapt7.

So how is 10? Well very much like the



Curate's egg — good in parts. It's very much Windows as usual. I can't say it's faster than 8.1 and my games definitely suffer. My family pleaded to revert to Windows 8.1

So after finding out a) Microsoft grants an uninstall for only one month after the upgrade; and b) Microsoft's push update policy removes my ability to choose when to update, I pulled the pin and returned to 8.1

I'm sure we'll upgrade eventually and given time Microsoft will sort things out, maybe even listen to concerns being voiced about forcing updates and removing choice. But for now I'll hold off until things clear up.

Ian Hollis

I upgraded to Windows 10 on two of our desktops, one running Windows 7 SP1, the other 8.1. The install went smoothly and surprisingly quickly, except during the installation process Microsoft installed a new Nvidia driver for my graphics cards (GTX 750TI and GTX 970 respectively). This meant I couldn't run any Steam games. Re-installing an older driver soon fixed that though.

All in all, it's a stable platform, but for me it has no real advantages over previous Windows 7 or 8, and support as ever is very poor (especially in Australia). Our business PC still runs Windows 7 and we'll stick with that for the next couple of months.

Peter Hayes

I've had a similar experience with the customised 'Get Windows 10' vs the media creation tool. Because I have a few laptops and desktops in the house, I downloaded the media creation tool to a USB and used Virtual CloneDrive to install Windows 10 on two netbooks, a notebook and the Windows 8 partition of my main computer (I run a dual boot system). This all worked flawlessly although the notebook is a bit touchy and sometimes has boot problems.

This encouraged me to take the plunge and upgrade the Windows 7 partition of my main computer. I clicked on the upgrade button and had spinning dots for an hour before I figured out that it wasn't working and rebooted. I then went into Windows



Update and the upgrade was there, so I went ahead with it and an hour or so later I had Windows 10 installed. However, the internet connection kept dropping out and none of the changes I made to the firewall settings made any difference.

The internet connection wasn't the only problem, but it was a showstopper. I reverted back to 7.

Bill Stomfay

I tried to upgrade an activated copy of 7 on a PC that the pre-release ISOs happily installed on. The 10 upgrade refused to complete, insisting I was missing important drivers. I wasn't. This idea that you have to do an upgrade to in effect convert your 7 key into a 10 key rather than just letting you do a clean install is truly bizarre.

Every attempt to get 10's final version onto a PC has been blocked by Microsoft insisting on this or that or something else. Every attempt has required hours of downloading of gigabytes of data — which for those of us who don't have access to cheap fast internet is quite expensive. I can't believe any company could put so much effort into stopping someone from actually trying its product.

Gordon Drennan

I know I should have waited until my APC arrived, but I upgraded anyway. I let Windows do the job by itself. Until now, the only issues I had are the time (I adjusted the format); my printers

went missing (went to Device Manager, and switched on printer, then it was eventually found, and works); and, when I shutdown it just reboots (went to Power Management, and found the On/Off button, but this does the same thing as the soft switch to shutdown). Any pointers for this one?

David

I have upgraded three PCs to Windows 10 with no problems during the upgrade. The main problem with 10 is backward compatibility with old programs and drivers. Even the 32-bit version only supports programs designed for Vista or newer. A few programs that worked with no need for compatibility settings before now don't work, and can't be uninstalled as even the uninstaller didn't work. Some programs and drivers have to be reinstalled, but even after reinstalling the correct drivers one of my printers didn't work.

My other problem is OneDrive. The folder cannot be moved to a removable SD drive. This is a problem on tablets which have limited storage. Another problem with OneDrive is that all synced files must be stored locally.

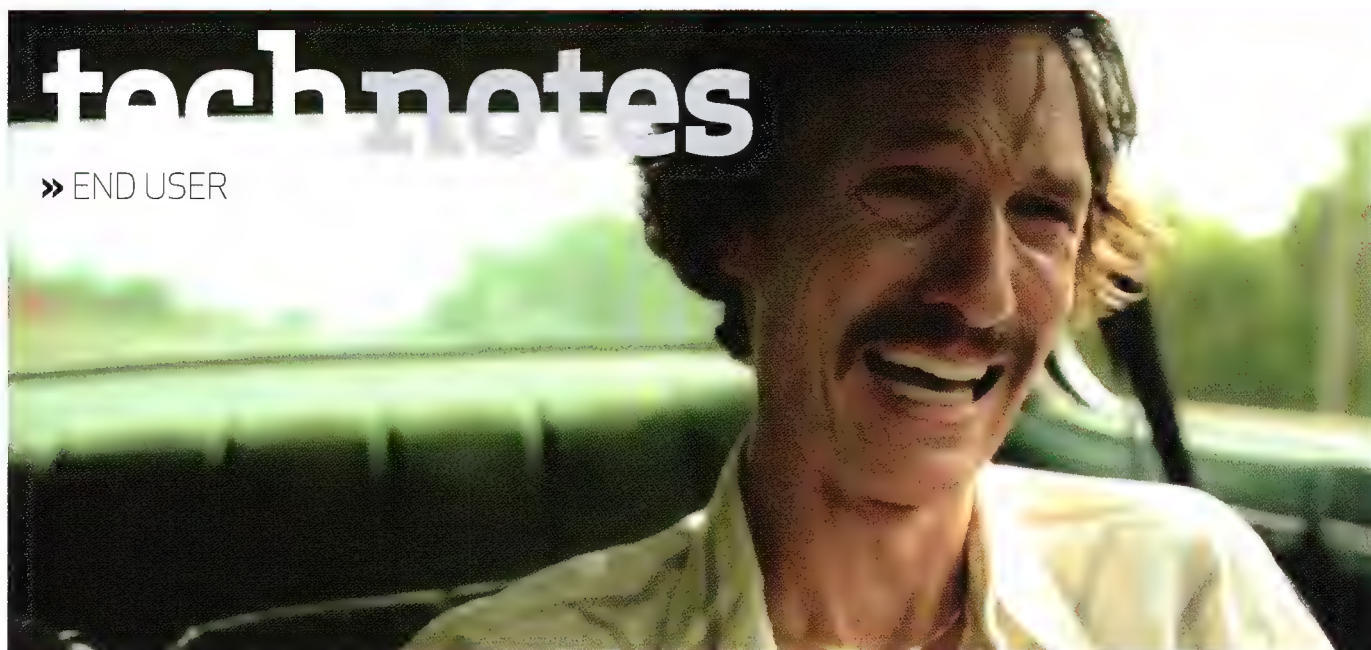
Although the PCs boot faster especially the laptop upgraded from 7, the delay on the laptops before any applications can be used is longer.

Carl Francis ■

APCMAG@FUTURENET.COM

Come on, have your say!

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Dallas Buyers Club LLC suffers a major blow

Stephen Lambrechts investigates the ramifications of the latest *ii*Dallas ruling.

It wouldn't be an exaggeration to say that the decades-long war between copyright holders and copyright infringers has become more heated in the age of the internet, with big time movie studios putting their money where their mouths are and taking their fight to the Australian Federal Court.

Even the most remorseless pirate understands why these companies want what's rightfully owed to them – but, for many it's harder to sympathise with copyright holders when the methods they employ often overstate the damages and pressure users into settling for large sums outside of court.

Recently, the Federal Court of Australia ruled that ISP *ii*Net would have to hand over the names and contact details of alleged downloaders of *Dallas Buyers Club* to its copyright holder, Voltage Pictures. Justice Nye Perram did so under the proviso that any letter sent out by the production company would be court approved.

Instead of demanding reasonable restitution for lost ticket and DVD sales, it was clear from the submitted draft letter and proposed phone script that *Dallas Buyers Club* LLC would instead attempt to use fear tactics to scare offenders into out-of-court settlements.

The proposed letter asked alleged pirates probing questions about their salaries, if they've served in the military, their previous torrenting history, how many times *Dallas Buyers Club* was downloaded off the back of their torrent and more. This would indicate that Voltage Pictures had plans to claim damages on multiple copies of the film from the one person, and would perhaps base those claims on the person's income.

The plan backfired, with the Federal Court ruling that the company would have to pay an enormous bond of \$600,000 to obtain the names and addresses of the 4,726 Australians that allegedly downloaded illegal copies.

Justice Perram made the decision to place such a large bond in an effort to prevent 'speculative invoicing', which is a practice that in this case would've seen rights holders approach rights infringers directly to seek significant amounts in compensation.

Seemingly unfazed by *Dallas Buyers Club*'s recent court ruling, Village Roadshow has thrown its hat in the ring by announcing it too will be going after infringers of its copyrighted material. Speaking to SBS, Village Roadshow's co-founder Graham Burke stated the company's intention to pursue pirates,

saying that "the criteria [for doing so] will be a person who is pirating movies." Burke then went on to say "we won't necessarily know who they are, but if they're pirating movies on a fairly large scale they're clearly doing the wrong thing," leading us to believe that this supposed plan of attack may take a different approach and target bigger offenders, although that's obviously speculation at this early stage. Burke also went on to warn that "if piracy isn't addressed, there won't be a *Casablanca*, there won't be a *Red Dog*, and there won't be a *Gallipoli*. There won't be the business model that allows them to be made," which is perhaps a little strange – not just because those movies already exist, but because the multiplexes we visit tend to only screen safe flicks and billion dollar-earning blockbusters.

We obviously understand the frustration that media companies must feel over the potential loss of revenue that piracy may cause, however it's hard to take these comments entirely seriously when three of the top six highest-grossing movies of all time were released this year alone. Perhaps this energy would be better spent trying to provide wide, timely and affordable access to digital films, rather than attempting to squeeze torrenters. ■

ENDUSER

Share your stories!

If you have an interesting story about technology users, their experiences and the issues that affect us all (whether funny or serious), email us at apcmag@futurenet.com. All correspondence becomes the property of APC and is subject to editing. Letters must include writer's full name, street address, suburb, state and phone number to be considered for print publication. Address and phone details will not be published.

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BENCHMARKS

	ASUS STRIX FURY DC III	AMD RADEON FURY X	NVIDIA GEFORCE GTX 980
TOTAL WAR: ATTILA (FPS)	18/26	19/27	24/32
PROJECT CARS (FPS)	45/52	49/57	52/58
WITCHER 3: THE WILD HUNT (FPS)	46/51	44/50	41/48
SHADOW OF MORDOR (FPS)	34/62	29/66	47/62
3DMARK: FIRESTRIKE EXTREME	6,909	7,415	6,345
FURMARK STRESS TEST (°C)	70	50	79

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ASUS STRIX R9 Fury Direct CU III OC

A flagship card oozing silent gaming fury.

AMD has fallen short in the last month. With many hoping the red team would pull back a win from the boys in green, it was with disappointment that we witnessed those Fury X benchmarks. All in all, the battle seemed lost. The war was over. Until now.

The standard Fury is a different beast entirely. Although being the little brother to the Fury X, and still housing the same memory and GCN architecture setup, there's one major difference between the two – AMD doesn't make these cards. Which is why we've arrived here at the overclocked edition. Coming in at an impressive 1,020MHz overclock, 30MHz less than the Fury X, this card features 500-odd less stream processors than its big brother. However, if the GTX 980 Ti taught us anything, it's that having less CUDA

cores or stream processors doesn't necessarily take you out of the running.

But let's talk about the card itself. ASUS is one of the first companies to take on the challenge of fully automating its PCB production line. The entire card – from chip and memory, to board and capacitors – is built by robots. What this means for us end users is no more soldering, no more flux and no more sharp bumps. The level of reliability and quality control is fantastic.

That's all good and dandy, but how does the card actually perform? The DC III has been under request for years, and for cooling capacity, the Strix does not disappoint. Providing three 92mm fans to cool two exclusive 10mm direct GPU contacting heat-pipes, this card has phenomenal GPU-chilling potential.

What ASUS has done here, however, is analyse how this

cooling is applied. Instead of trying to keep the card below 30–40°C at all times, it's worked on making sure noise control is the top priority. Each fan runs independently on a 0dB fan curve, as has become quite common recently. However, unlike the vast majority of the competition's solutions, this 0dB technology is embedded into GPU load, as opposed to temperature. What this ensures is that as soon as you're out of game, your card isn't creating any unnecessary noise to cool down a GPU that can gently ramp down anyway.

When it comes to performance, this is where ASUS and AMD to some extent blew us away. For a card that comes in to the market at roughly \$999, it performs incredibly well. Overclocking, we managed to push the core clock up another 100MHz over stock (70MHz over ASUS's stock settings). Yet even as we

dialled back for our benchmarking process, the scores were still only a few frames per second behind the Fury X. We utilised GPU Tweak II to achieve this, as ASUS has allowed access to the power limit feature within the card. It's worth noting, however, that High Bandwidth Memory (HBM) still doesn't overclock at all.

All in all, this card is brimming with neat features and it performs almost as well as AMD's flagship for a price comparable to a GTX 980. It's a phenomenal bit of hardware. ■ Zak Storey

Verdict

Features ★★★★★
Performance ★★★★★
Value ★★★★★

Stunning build quality; impressive cooling design; strong performance; great price.





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Apple iMac with 5K Retina display (3.3GHz)

All the pixels for less. Is the entry-level Retina iMac still a killer desktop?

We absolutely loved the 27-inch 5K iMac when it first appeared late last year. The base model rivalled the Mac Pro for computing power and gave us that amazing 14.7M pixel screen. The only downside was price. So, what corners were cut for this new entry-level option?

First, the processor is a 3.3GHz unit compared to the 3.5GHz in the higher model. But it's still an Intel quad-core i5 chip, and it seems the only difference between the two is pure speed, and not a big one at that. Benchmarks suggested we'd see a less than 10% difference in single-core performance (which is what you need for many standard tasks around the operating system and simple apps) and multi-core (for intense pro-level tasks).

The gap was even less than we expected in our real-world video encoding test. Given that both models come

with the same amount of user-upgradable RAM, for a lot of uses you'd see no appreciable difference.

The graphics chip has also been changed — the AMD R9 M290X becomes an AMD R9 M290, though losing the X makes more of a difference here. They both offer 2GB of video RAM, but our *Batman: Arkham City* 1080p test performance dropped considerably from 88fps down to 55fps.

That said, performance in *Tomb Raider* was much closer, dropping from 49fps to 42fps when played at 2,560 x 1,440 on High detail settings. In all cases, it means demanding games are very playable, though you won't want to crank them up to the full 5K resolution.

The one major difference between the two iMacs is likely to be the biggest one for performance: storage. This entry-level iMac comes with a 1TB 7,200 rpm HDD as standard. If you're planning

to use the 5K iMac for high-level photography or large-scale video work, you're going to need a lot of storage space. That's where HDDs excel, no question — but we want the blistering speed of an SSD in such a high-performance machine.

Those are the changes and the key element in the iMac that remains the same is the astonishing 27-inch 5K Retina display. Everything on it looks amazing, from any angle, with accurate colour reproduction. It's also a huge amount of space to work in, providing detail for creative apps, or the ability to have multiple docs open.

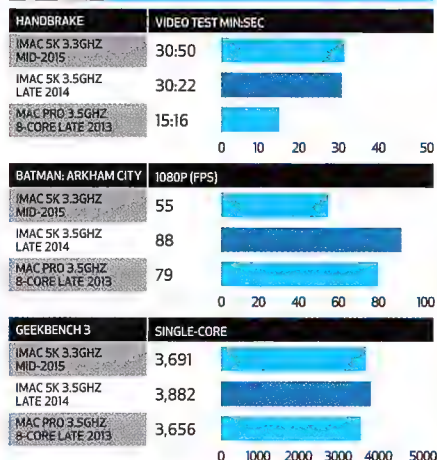
You've also got all the usual iMac connectivity options: two Thunderbolt 2 ports, four USB 3.0 ports, Gigabit Ethernet, an SD card reader and headphone jack, along with 802.11ac Wi-Fi and Bluetooth 4. All that takes up relatively little desk space for its size. The speakers are surprisingly

good, and it's not too noisy, though with intense 3D tasks, it doesn't take long for the fans to kick in heavily.

It's an excellent machine: lots of CPU power, graphics capability, and that glorious display. But we believe you should be looking at an SSD or Fusion Drive for longevity, which means you might as well go for the next one up at \$3,199. If you're certain you won't mind having only a HDD and want to save cash, then this is a great buy. Otherwise, we'd encourage you to invest in the upgrade.

■ Matt Bolton

LABS BENCHMARK RESULTS



Verdict

Features ★★★★★
Performance ★★★★★
Value ★★★★★

A more affordable 5K iMac, though the mechanical hard drive could be a sticking point for some buyers.





ASUS ZenBook Pro UX501

An affordable and impressive (but flawed) 4K laptop

This laptop is a follow-up to last year's ZenBook NX500, and it features a similar aluminium chassis, speedy SSD storage, and a 4K display – all at an attractive starting price. It comes with an Intel Core i7 processor, a 4K touchscreen display and a 512GB SSD.

From the outside, it could easily be mistaken for a 15-inch Retina MacBook Pro. The brushed aluminium, however, has subtle, concentric circles on the cover in keeping with the ASUS brand. Overall, the quality feels solid. And while it's clearly a rectangular slab, the machine is very stylish. The edges are gently rounded, and the inside surface sports bevelled edges that shine in contrast to the matte finish of the keyboard and palmrest.

The keyboard's backlight has minimal bleed and will fade away when you're not using the keys.

The laptop packs in the usual complement of ports, with three USB 3.0 ports,

mini-DisplayPort and HDMI. It lacks an Ethernet port, but ASUS bundles in a USB Ethernet adapter.

The touchpad is a tad stiff and not as smooth as on other laptops we've tried. The stiffness is not a dealbreaker, as such, but it is noticeable. More challenging is the keyboard itself. It could take you a while to adjust to the smaller spacing between the keys.

While we're griping, we also found the audio a bit tinny. The volume is also softer than expected, too. We had to put it to 75% to play music at a decent level. The loudness of the speakers is obviously affected by the surface you use the laptop on. When resting on a hard surface, where the downward firing speakers could reflect sound, it helped the audio. While, placing the laptop on a softer surface muffles the speakers and hampers the audio quality.

Everyday tasks were smooth. The touchscreen was responsive, as was the SSD. However, the battery life ranged from mediocre to

decent depending on the task. PCMark 8 estimated 3 hours and 20 minutes at maximum brightness. ASUS claims about six hours.

We eked out more time by lowering the brightness, and sticking to light web-surfing, YouTube viewing, and Google Docs work. But by around the five-hour mark, we were running low on juice.

On the plus side, we can't say enough good things about the display. The high-resolution 4K makes all the difference, whether you're watching videos, editing photos, or simply reading documents.

However, we weren't so keen on the weight of the laptop. Granted, other laptops with 4K screens often weigh more, but ASUS is taking on the 15-inch MacBook Pro which weighs significantly less. That makes a difference for the frequent flyer, for instance, or for anyone who wants to take this laptop on the go.

The ZenBook Pro looks terrific from the outside, and even better when you fire it up. This model stands up well

to its competition by delivering a solid punch of features and performance.

That said, battery life comes as a disappointment but it's decent considering the high-res screen. But if portability and a 4K touch display are paramount priorities, and you want to keep costs down, the ZenBook Pro will suit your needs. Just count on keeping the chunky power brick nearby, and not straying too far from a power socket.

But, the ASUS ZenBook Pro is inexpensive and is a strong buy on its strengths alone – including looks, good performance, 4K touchscreen and on-board storage.

Verdict

Features
Performance
Value



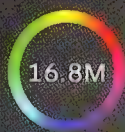
The ZenBook Pro has an aesthetic and performance that rivals the MacBook Pro for far less cash.



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BenQ EW2440

Pleasing to the eyes and pleasing to the wallet too.

With a 1080p full HD panel, the EW2440 is a 24-inch monitor that doesn't come with frills, such as 3D display, built-in colour calibration or touch support. Instead, you're paying for more accurate rendering of colours.

The EW2440 is capable of displaying 95% of the sRGB colour space, 70% of the NTSC colour space and 74% of the Adobe RGB, which is excellent (most good modern displays usually fall within the 85% to 100% range of sRGB).

There's excellent colour uniformity, contrast and colour accuracy, too. Our unit displayed dark blacks and high contrast, rich and vibrant colours without being over-saturated, and provided wide viewing angles and fast refresh rates. The display's brightness uniformity is only average, with the panel exhibiting a small amount of light leakage along the edges. This isn't a problem when viewing images with

brighter backgrounds, but it is obvious with movies set against a dark backdrop.

You get two HDMI input ports, with one of those supporting MHL for connecting a compatible smartphone, a D-Sub port, and lines in and out for audio, plus there are stereo speakers located on the left and right sides of the ports.

On the front base of the EW2440 is a small piece of black plastic. Once that plastic is lifted, it creates a smartphone stand that enables you to stand your phone on the dock and connect the MHL HDMI cable to project the content from your device to the larger monitor.

The obvious use for MHL output – which is supported on modern flagships like the HTC One M9, Samsung Galaxy Note 4 and Sony Xperia Z3 – is to enjoy videos and games. Given that the EW2440 also comes with built-in speakers, users should be able to enjoy multimedia by connecting the included MHL cable.

With flicker-free tech and

various preset display modes that help to reduce eye fatigue by removing blue light, the EW2440 does a good job keeping users comfortable while looking at the display for extended periods of time, especially at lower brightness levels.

Even though there is conflicting scientific opinion on the causal relationship of blue light and eye fatigue, we noticed that with the web or reading modes enabled, the whites on the screen warmed up. Rather than a cold, blue white, white backgrounds appeared more yellow, taking on a similar hue as parchment paper.

This, in effect, serves to reduce screen contrast, making for a more comfortable reading experience over longer durations. It felt more like reading printed text on paper.

Given its affordable price, we can't really fault the EW2440 for its plastic construction or rather uninspiring design. Our biggest gripe with this

display is that we couldn't get audio out from our devices to the display's built-in speakers over HDMI, MHL or a 3.5mm audio cable. It's unclear at this time what the problem was; it's likely a faulty test unit. For gamers, this one's slower refresh rates will also result in some ghosting when playing games with high frame rates.

The EW2440 joins a crowded space of 24-inch full HD monitors. At the price, this won't be the cheapest 24-inch screen on the market, but if you're willing to pay a little more, you'll be rewarded with a great display.

■ APC team

Verdict

Features ★★★★★
Performance ★★★★★
Value ★★★★★

Excellent colour reproduction, and refresh rates to help you stay productive and entertained.





WIRELESS MOUSE

\$99 | LOGITECH.COM

Logitech MX Anywhere 2

Smarter than the average mouse.

This is a great little mouse for laptop users – especially if you want something small enough to pack in a bag with your notbook. However, it's got two key features that make it especially good for use on the go.

The first is its Darkfield laser sensor, which not only sounds like a superweapon you'd use against the Avengers, but works great at detecting the mouse's movement accurately on just about any surface. Regular laser mice, explains Logitech, use irregularities in a surface to track direction and speed. The Darkfield laser does this to the nth degree, so no matter how shiny or plain or transparent the surface is, it still works.

Seriously, it does. We tried it on jeans, windows, shiny magazines... anything difficult, really, and it worked perfectly on them all, which means anywhere you take this out it'll be fine – it's great for

systems used as HTPCs, too.

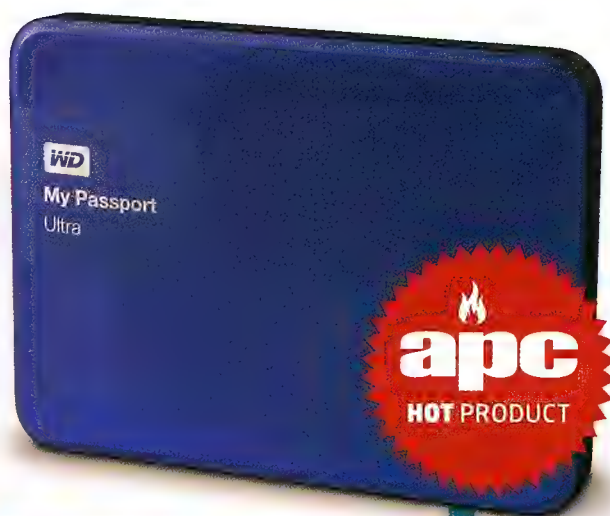
For MacBook owners, the other great feature is that it has a button on top that enables you to perform gestures without doing any trackpad multi-touching. You set up what kind of gesture it should be doing (say a three-finger gesture, or zooming) in Logitech's app, and then hold the button and move the mouse in one of four directions to trigger a gesture. We found the button a bit far back to press comfortably, but it offers loads of possibilities for either creative work or just getting around OS X.

A really well-made mouse that works everywhere and has useful Mac gestures.

■ Matt Bolton

Verdict

Accurate movement detection anywhere in a compact, nicely made unit.



EXTERNAL HARD DRIVE

\$285 | WESTERNDIGITAL.COM

WD My Passport Ultra 3TB

Is WD's surgery on the popular My Passport Ultra drives a good thing?

This year's Western Digital My Passport Ultra models don't look all that different to the versions that preceded them. They're still encased by that shiny black plastic and though they may be fractionally thicker than previous iterations, they have an almost identical physical footprint.

But there are some considerable differences to be found in the new Ultra drives and the first glaringly obvious one is; the company's ditched the 500GB version for one of the biggest single portable-sized external hard drives we've seen at 3TB.

This 3TB Ultra isn't just bigger either, it's also between 5 and 10% faster than any other similar portable drive on the market – at least that we've tested. Though there is always the possibility that WD has tweaked the USB 3.0 data transfer interface, the additional speed is most-likely due to the density of

the new drive, meaning the mechanical components actually have less physical distance to move, fractionally speeding up read and write times.

This 3TB model even manages to maintain WD's comparatively low cost per gigabyte ratio – although you will ultimately pay twice the price of the 2TB equivalent for this unit, so there is still a premium to getting this much space in a compact size. It includes WD's well-rounded software suite, which includes the WD Backup, Security and Utility apps that, based on previous testing, work equally well on PC and Mac. If you need lots of portable storage, this one's genuinely hard to fault.

■ Joel Burgess

Verdict

Lots of storage in a relatively compact form, but pricier per GB than its 1TB and 2TB siblings.





PC CASE

\$179 | WWW.BEQUIET.COM

Be Quiet! Silent Base 800

Fantastic noise cancelling, but could do with more modularity.

Since Be Quiet's 2008 inception, the company's ethos has centred around one thing: silence-optimised PCs. So, it wasn't a huge surprise when late last year it announced the first iteration of its case line, the Silent Base 800. And it's a sound-sensitive builder's wet dream. The steel chassis houses noise-dampening plastic panels lining the case, including the bottom. The case design is fairly modular. The included 5.25-inch bay cannot be removed, but the two 3.5-inch drive cages below this can be taken out to allow for better airflow from the two 140mm pure wings fans in the front. In the rear compartment, you're provided with ample cable management space. The back of the 'board tray houses two 2.5-inch drive bays as well. For cooling support, you're looking at room for a 240mm or a 280mm radiator in the roof and the front of the chassis, with plenty of space for

push pull, and an additional 120mm fan (also included) in the rear. This chassis does face some stiff competition from Fractal's Define R5, however, one of the most recognisable silence-oriented cases available. It's a contender, no doubt, but the 800 simply doesn't cut it when it comes to the build quality of the panels. With a soft-touch finish, the plastic feel and strength of the panels is less than ideal. The Silent Base 800 is deafeningly quiet, but it feels a little too rigid for our liking. There's not enough customisation internally, and the inclusion of such a large 5.25-inch drive bay makes no sense in a case that's meant to be quiet.

■ Zak Storey

Verdict

Great noise dampening; good looking design; but it's a shame it's plastic.



MECHANICAL GAMING KEYBOARD

\$220 | GAMING.LOGITECH.COM

Logitech G310 Atlas Dawn

This compact keyboard is the Hans Moleman of gaming gear.

Doing its best to remain cool and relevant in a market space that has blasted by it at the speed of light, Logitech's Atlas Dawn is the 'ten-keyless' edition of the Orion Spark that we reviewed back in APC 411. It's also, sadly, sans features too.

The board is decked out with Romer-G mechanical switches similar to those in the Orion, and again have a comparable "mouth-feel" of a Cherry Blue, but without the accompanying, satisfying clack sound. The Romer-G also sports Facet Keycaps which are weird angular H-shaped indents on every key. It almost locks your 'tips into the keys. While that's fine for gaming where there's minimal finger and hand movement apart from around the WASD base, they're dreadful when it comes to banging out sentences and paragraphs; at least for those of us who aren't classically trained typists, where fingers can feel like they're tripping

awkwardly over key edges. We'd have preferred regular caps with perhaps a bonus set of gaming caps bundled in.

One feature we do like is the smartphone/tablet dock that tucks away into the top edge of the board. Jump on to your phone's app store and grab Logitech's Arx Control app (plus the PC equivalent) and you have a pretty cool little asymmetrical system monitor.

It's the nicities that Logitech have excelled at getting really wrong. Running through the list of missing features, there's no braided cabling, no additional USB passthrough, no audio/mic jack and no money left in your pocket after outlaying the \$220 RRP. If you're looking for a compact mechanical board, there are far better offerings for far less money. ■ Troy Coleman

Verdict

An expensive compact mechanical gaming keyboard with weird-feeling keys and minimal features.



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Vigor2760 Series

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Vigor2860 Series

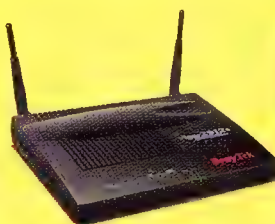
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Vigor2912 Series

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- 16 x VPN tunnels with hardware accelerator & VPN Failover
- Advanced Wi-Fi for Vigor2912n



Vigor2925 Series

- Dual Gigabit WAN ports with 3G/4G Load Balance and Failover
- Five Gigabit Ethernet LAN ports with 50,000 NAT sessions
- 50 x VPN tunnels with Central VPN Management & 25 x SSL-VPNs
- IEEE 802.11ac wireless Access Point for Vigor2925ac
- Advanced Wi-Fi/Dual-Band Wi-Fi/VoIP functions



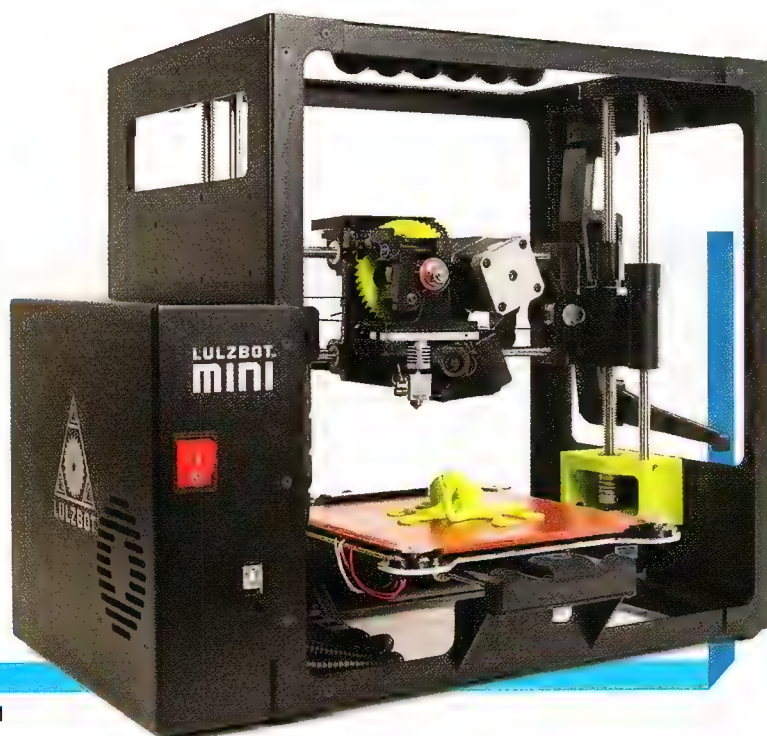
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www.i-lan.com.au

(02) 9838 8899

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3D PRINTER

\$2,190 | WWW.LULZBOT.COM

LulzBot Mini

A 3D printer that rocks your world and can print Cthuhlu to destroy it.

LulzBot 3D printers are visually distinctive with their black steel metal frames and inner workings on display. The printer looks like it's been taken from a science lab. As we would expect the hardware is accessible and you can update it as you see fit – at least as long as you have the skill.

Fabricated steel sheets form the basic shape of the printer and while this form of casing may be pretty primitive, the quality of finish and the weight of the material that's used gives the machine a reassuringly solid quality. Altogether the whole machine weighs 8.55kg and this is just enough to keep vibrations caused by the stepper motors to a minimum while ensuring the printer is easy to move about.

The main power supply and control panel are hidden away in the main casing to one side of the unit, but the rest of the machine is open so all of the print head and build area can be seen during

the print process. The LulzBot Mini features a heated print bed that measures 15.2 x 15.2cm and will print to a height of 15.8cm – not a bad size for a printer with the small designation.

The design of this print bed means that it moves along the y axis while the print head moves along the x and z axis. This print size compares well against the Ultimaker Go, which features an unheated print bed at 12 x 12 x 11.5cm, and the more expensive Ultimaker 2 with a 23 x 22.5 x 20.5cm heated build plate.

When it comes to loading 3D models you will need to connect the LulzBot Mini directly to a computer via a USB cable, and this connection must remain during the print process.

Filament loading and swapping is relatively straightforward. The control panel in the Cura software is used to heat the head, and then the spring-held filament clamp, above the head, can be released by hand and the filament

removed and replaced. The process takes a couple of minutes just to wait for the head to heat but it's far easier and less frustrating than many other printers, including the Ultimaker 2, which this author's also spent some time with.

The unboxing to print time is around twenty minutes. Once hardware and software are in place and connected by USB, the Cura software needs to be configured, but this is easy enough with a walkthrough setup and a decent set of instructions that quickly get you to the point where you're ready to start printing. It's suggested that you download and print the Rocktopus model for your first print and test that the printer is working correctly. With the model loaded into Cura all you need to do is hit 'Connect' and then print.

The LulzBot Mini takes 3mm filament. In our testing we used PLA, ABS and HIPS which are the preferred materials. Prints using all three types of plastic turned out well using a variety of

settings. The software includes a direct access to the fine adjustment of the hot-end and print-base temperatures which is a nice touch.

Overall print quality was good with resolutions ranging from low, at 500 microns, to a respectful 50 microns. When compared to the quality of a print from the Ultimaker Go, we could see a difference in the fine detail of the print giving the Ultimaker Go the edge in quality. But the Ultimaker lacks versatility when it comes to supported materials and adjustments available compared to the LulzBot.

■ Pablo Sanchez

Verdict

Features	★★★★★
Performance	★★★★★
Value	★★★★★

Features a decent-sized print base, respectable resolution and supports a huge variety of materials.





SMARTPHONE
\$449 | OPPO.COM

Oppo R7

Chinese quick-draw hits its mark.

Though the company has been selling its phones in the Australian market for some years now, it's possible that you haven't actually come across Oppo before. In China however – which represents 30% of the total global market – Oppo is actually as popular as Samsung, if not moreso.

And though Oppo's smartphones come in at a reasonable price, the appeal – including the R7 – stems more from the premium finishes, usable operating system and unique added bonuses. Through Optus, you can pick this one up from \$40 per month on a plan that includes 500MB of data, or purchased outright from Oppo for \$449. When you consider that it has a 1.4GHz octa-core processor that achieves respectable work and gaming scores on benchmark tests, the R7 starts to look like a solid mid-range smartphone. Then take into account the full HD AMOLED screen that can turn pixels off to create

much better contrast ratios and the soft feel of the fractionally convex Gorilla Glass touchscreen and the R7 continues to tick the right boxes. Throw in an elegant full-metal case that feels and looks a lot like Apple's latest – and arguably sits in the hand even better – a lightning fast charging system that'll fill 75% of the battery in under 30 mins and a clean Android OS, and the R7 becomes an impressive feat in mid-range smartphones. If you're not looking to fork out a small fortune for the latest high end flagship but don't want to be constantly reminded that you went for something cheaper, it'll be hard to find something better than the Oppo R7. ■ Joel Burgess

Verdict

Quality screen, fast charging, good OS at the right price. An excellent mid-range phone.



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A real pocket rocket

THE SAMSUNG PORTABLE SSD T1 IS THE ULTIMATE IN PORTABLE STORAGE.

Designed for creative professionals and demanding business users on the go — or anyone who just wants a slick and speedy storage device — the Samsung Portable SSD T1 houses up to 1TB of Samsung's class-leading solid-state NAND flash memory in a very compact package. And with USB 3.0, there's no bottlenecking when you're copying data to and from your PC. It's the no-compromise storage device that combines amazing features with a sleek and stylish package.

FAST

The Samsung Portable SSD T1 is built from the ground up for speed. Taking advantage of Samsung's extensive SSD know-how, the T1 range offers read and write speeds of up to 450MB/s* — that's up to six times as fast as a regular mechanical hard drive. That means it's fast enough to tackle almost any storage-intensive task you can throw at it. Whether you're editing 4K video or just looking for the quickest loading times in games, the T1 won't leave you waiting.

SAFE

When it comes to data security, the Samsung Portable SSD T1 also has your back. With virtually uncrackable hardware-based 256-

bit AES encryption onboard, you can protect your data from prying eyes. And when you want to access your private files, it's just a matter of entering your password. It's not just encryption that protects your data either. With solid-state technology, the T1 doesn't have any vulnerable moving parts, meaning it's much better-equipped to stand up to the rough-and-tumble that portable drives inevitably experience.

STYLISH

Samsung hasn't compromised in the style department either. With a classy and sleek black polycarbonate chassis, the T1 packs all that storage and speed into a package that has a footprint that's around two-thirds the size of your average business card. Images don't do justice to how compact the T1 really is: you need to see it in person. This is an elegantly-designed drive with a thin profile and, weighing in at a tiny 30g, it can easily slip into a shirt or pants pocket without being a burden.

In short, the Samsung Portable SSD T1 delivers a mass of speedy storage that comfortably fits in the palm of your hand, all based on Samsung's trusted SSD expertise. With the T1, Samsung hasn't compromised — so you don't have to either.

SPECIFICATIONS
CAPACITIES
250GB, 500GB, 1TB

INTERFACE
USB 3.0 (COMPATIBLE WITH USB 2.0 DEVICES)

TRANSFER SPEED
UP TO 450MB/S*

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OPTIONAL 256-BIT AES ENCRYPTION WITH PASSWORD SETTING**

DIMENSIONS (W X H X D)
71.0 X 9.2 X 53.2 MM

WEIGHT
30G

WARRANTY
LIMITED 3-YEAR*

*Performance benchmark product: T1 (500GB). Performance can vary depending on host configuration and test software.

**Users can select security option during the initial registration process (For more details, please refer to the manual).

*See <http://www.samsung.com/au/support/warranty> for further information.





software

» APPS FOR ALL THE PLATFORMS



Windows SOFTWARE

VirtualBox 5

After almost five years in incubation, the latest release of VirtualBox adds many much-needed features.

FREE | WWW.VIRTUALBOX.ORG

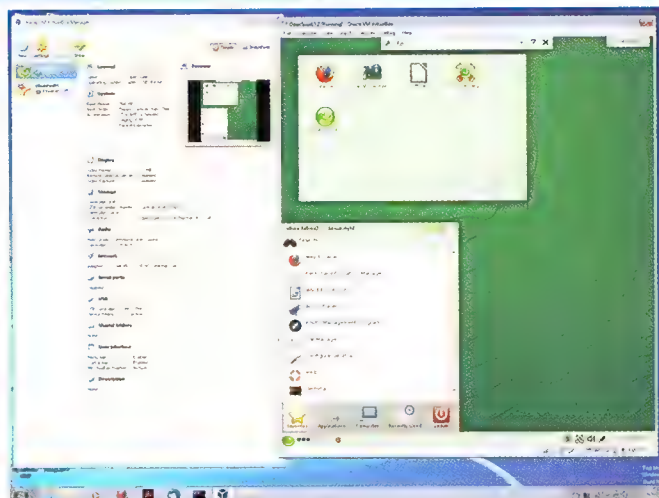


VirtualBox had its last major release, 4.0, back in 2010. Since then, the desktop virtualisation software had been lingering in point releases and losing out to paradigm shifts in the virtualisation arena. But with VirtualBox 5.0, its putting up a strong case for hypervisor-based solutions.

The new release incorporates several new features. That includes things like exposing a broader set of CPU instructions to the guest OS, meaning apps running inside virtual environments will be able to make use of these for better performance.

A highlight of 5.0 is the addition of paravirtualisation (PV) methodologies, namely Hyper-V for Windows and KVM for Linux. This should significantly boost the performance of the guest OS by using its built-in virtualisation support. Another highlight is disk encryption. At the expense of some performance, privacy conscious users can encrypt new and existing virtual disks using AES with either 128-bit or 256-bit keys. Once this is enabled, however, you'll lose the ability to restart the machine unattended, since you'll need to enter the disk encryption password when the machine boots up. Also note that you can enable this feature only if you install the proprietary VirtualBox Extension Pack.

Other new features include improved bi-directional sharing, so you can drag and drop between host and guest on all host platforms running Windows, Linux and Solaris guests.



While the overall interface for creating and managing virtual machines is pretty much the same, several sections in the virtual machine settings now expose the added functionality with new tweakable options. For example the System section has a new pull-down menu under the Acceleration tab to select a PV interface, and the Storage tab now lets you mark virtual disks as hot-pluggable devices in addition to SSDs. Similarly, the Display section boasts new functions under the Video Capture tab.

The Settings window adds a new User Interface section for customising the UI for the virtual machine controls. Besides enabling or disabling complete menus, you can also optionally remove specific sub-menu options, so you can retain the Machine menu and remove only the Reset option from the interface for a particular virtual machine to force users to shut it down properly.

All in all, VirtualBox 5 does enough to justify its dot release status. With paravirtualisation and USB 3.0 support, it's got new features for both advanced and average users and the ability to run encrypted virtual images is a boon for all security conscious users.

Shashank Sharma



Sway

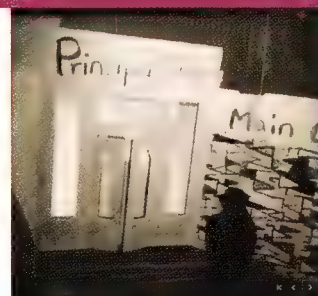
FREE | SWAY.COM
ALSO ON IOS, WEB

Though it may seem counterintuitive for Microsoft to be working on an application that will compete directly with its dominant presentation software PowerPoint, after using Sway it's a little easier to understand why the company's gone down this road. Sway has been built to cater to a modern audience and a number of design choices make it clear that this presentation application is part of Microsoft's push to stay relevant in the future. The first aspect that makes the generational differences between PowerPoint and Sway clear is the fact that Sway is primarily a browser based application, with optional stand alone smartphone and tablet versions. But not only does Sway mirror the company's broader trend to make its apps and services available on more platforms simultaneously, it also adds features that reflect more modern presentation requirements. YouTube videos can be embedded directly into slideshows, for example, and the app features the ability to present multiple windows at

Sample short film produced by teachers.

A small group of teachers were inspired by the symbolism of stairs in the film exhibit.

Check out the video to see how they used them in their short film.



once in a tiled layout. Sway uses OneDrive cloud storage so you can store and access a generous number of presentations from any device using a free Microsoft account. Sway is a simple to use, streamlined app that has enough of the right features to actually feel more sophisticated than its predecessor.

Joel Burgess



Alternote

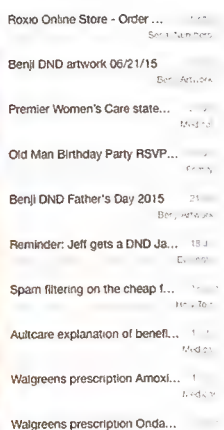
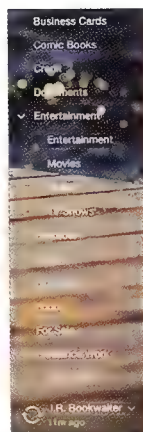
A stripped-down alternative client for Evernote.

\$6.99 | ALTERNOTEAPP.COM



As the name implies, this is an alternative to Evernote's "everything including the kitchen sink" app approach; an alternative which requires users to pay for the privilege.

Is it worth the money? For the most part, yes. We linked our account and within minutes synced nearly 600 entries directly from Evernote's servers (your stuff is never accessible by Alternote's creators). The application is quite responsive; users with more than 2,000 notes are recommended to selectively sync notebooks. The interface is familiar enough for Evernote veterans, with an optional sidebar displaying categories for All Notes, Starred, Notebooks, and Tags.



Clicking your account name in the bottom left corner allows users to change the background. Should you prefer a darker theme overall, "night mode" is available from the font settings or view the note currently being edited in distraction-free mode.

Even in regular mode, however, Alternote does its best to keep the UI out of the way. When the sharing, settings, and tag options disappear, keeping the focus on text entry. Text styling any note text pops up a handy toolbar with formatting options. There are also keyboard shortcuts that can take place without ever touching the mouse or trackpad.

You'll still want to keep that free Evernote client around, though: Alternote can't display PDF files out to Preview (inline photos display just fine, however). There's also no import option compatible files can be dragged and dropped into an open note.

The bottom toolbar includes basic text formatting options, providing a distraction-free environment for committing notes and ideas to virtual paper. — J.R. Bookwalter

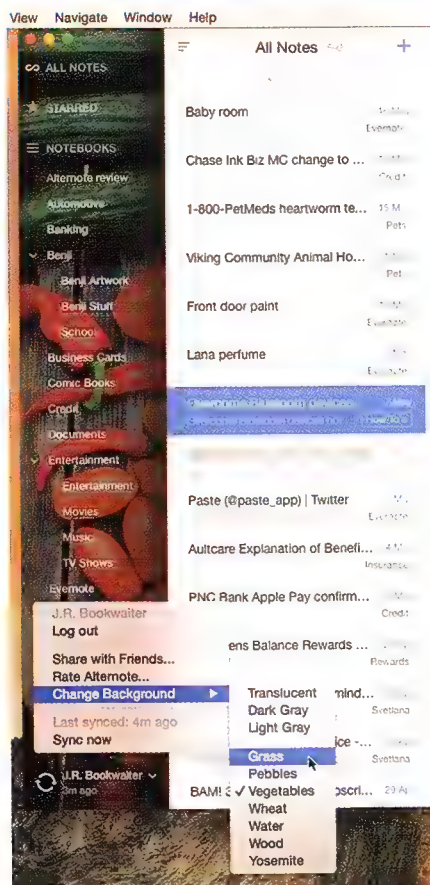
You can change the background colour of the sidebar, and there's a Night mode, along with the option to view the note currently being edited in distraction-free mode. As you write, the sharing, settings, and tag options disappear. Text styling is entirely WYSIWYG; double-clicking pops up a handy toolbar with formatting options. There are also plenty of keyboard shortcuts.

Alternote can't display PDF files saved within notes, kicking them out

to Preview for viewing (image files are displayed inline, however). There's also no import menu option, although compatible files can be dragged and dropped into an open note. Other features like shortcuts, shared notes, and business notebooks are currently missing, but are promised by the developers with future updates.

A distraction-free environment for committing notes and ideas to virtual paper.

J.R. Bookwalter



Serif Affinity Photo

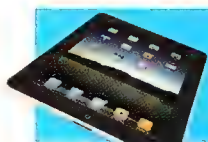
\$49.99 | AFFINITY.SERIF.COM



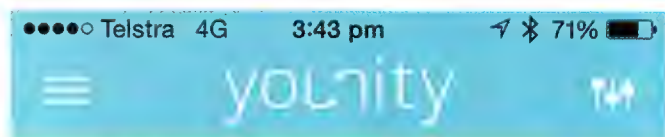
Affinity Photo is designed not as an amateur Photoshop wannabe, but as a direct Photoshop

rival — and at first sight, Affinity Photo does look a lot like Photoshop. There is a difference, though. At the top left of the window is a row of "Personas," which put Affinity Photo into different editing modes. The Liquify persona is just like the Liquify window in Photoshop, but feels faster and more fluid. The Develop persona is the equivalent of the Adobe Camera Raw dialog in Photoshop. It lacks a little subtlety compared to Adobe Camera Raw, though it has a full range of colour and tonal adjustment controls, and it's also possible to apply localised adjustments with gradient and brush tools. The Export persona is for exporting your images in a range of formats using adjustable parameters and presets. The Photo persona is where you do all your serious work. Affinity Photo uses its own file format, but it can import and export Photoshop PSD files. It will also work directly with Photoshop-compatible plug-ins — you simply locate your existing plug-ins folder within the Preferences dialog. If you're familiar with Photoshop and other image editors, it won't take you long to find your way around. It packs most of Photoshop's main features, like adjusting Curves, Levels, Black and White and so on as non-destructive layers, plus powerful retouching tools. There are even a few unique ones like non-destructive scaling. Affinity Photo is a far cry from Serif's budget Windows programs; this is a fast, efficient and genuine Photoshop alternative.

Rod Lawton



App Store » iOS APPS



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All Files



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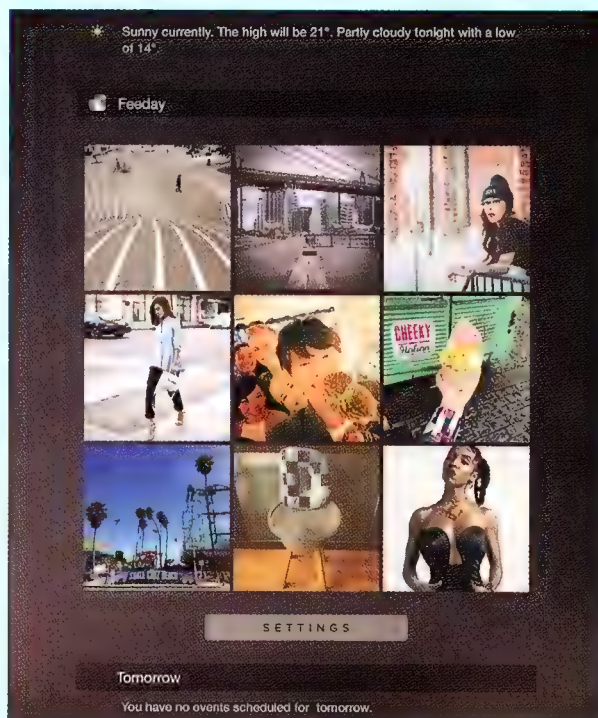
Younity

Simple app and computer file sharing.

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Feeday

FREE | WWW.FEEDAYAPP.COM

Looking to add some colour and liveliness to your iPhone's boring drop down screen? Well you're in luck, because Feeday lets you apply a widget in that area that will pull in the latest photos from your Instagram feed. The free version will display your feed's top three images, or you can upgrade to six or nine images for a small fee of \$1.29 (though we're not sure why you'd opt to buy the six image version at the same price). It's a cool widget that makes your iPhone feel a little bit more Android-esque (if that's something you want), however we do wish that it would be a little more interactive — tapping on a photo will open it up in your Instagram app, though we kind of wish you could scroll through images by swiping across them. Still, Feeday is worth trying out if you regularly visit your Today menu and think it could do with a little bit of redecorating. **Stephen Lambrechts**



Fleksy

FREE | FLEKSY.COM



While your iPhone's standard keyboard is already great, there's nothing wrong with checking out other options, either. Fleksy is a new player in the predictive text keyboard scene, and it has certainly arrived dressed to impress. Customisation is the main focus of Fleksy, sporting a range of stylish themes (some requiring in-app purchases), colours and extensions which let you tailor your keyboard experience to your needs. While it's pretty easy to use for standard text input, there's a steep learning

curve to getting the most out of its features. Swiping from right to left deletes the last word you've typed, while swiping up and down lets you scroll through predictive text suggestions. This works decently, though predictions stumble on some words that the standard iOS keyboard would easily pick up on. Still, Fleksy does a great job of figuring out what you're trying to say for the most part. Extensions let you add a numbers row, GIFs, emoji, modes for improved one handed typing, and more. Recommended. **Stephen Lambrechts**

Pause

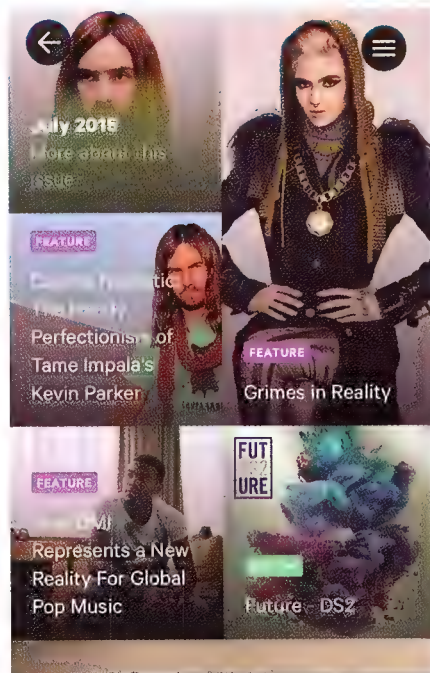
The best thing for music since Rolling Stone.

FREE | PAUSE.FM



Pause has been available on Android and iOS since late last year, and with a recent update bringing a totally new interface we thought it deserved some fresh attention for anyone missed its earlier incarnation. Pause is a curated online magazine that collects some of the best music articles that can be found on the web, reformats them to look beautiful on a phone-sized screen, then adds an interactive curated playlist of the artist's music that's covered in the text. The clients for both Android and iOS aren't just well presented, they're

also highly intuitive and easy to navigate. You also have the ability to filter articles by type and source, so you can hone in on specific types of content including features, interviews, mixtapes and new-release lists, to name a few. Pause has been releasing monthly issues since January and also produces quarterly and yearly in-app publications. When we first covered it, there was undoubtedly a lot of potential, but 7 months in Pause has transformed into an app that we'd consider essential for every music lover. Joel Burgess

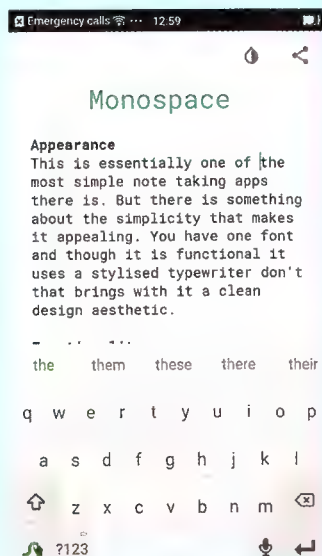


Monospace Writer Beta

FREE | TINYURL.COM/PMFW2J



Monospace Writer is one of the most simple note-taking apps you'll find. But there's something about that simplicity that makes it appealing. You have just one font — a stylised typewriter-like serif — that's purely functional, though it does bring with it a clean design aesthetic. You can style text by simply highlighting it, with the options to bold, italicise, configure bullet points or copy text maintaining the perfect balance between usability and simplicity — ideal for a smartphone note-taking app. Monospace has also colluded with Dropbox so you can backup your notes in the cloud, allowing you to access them from various devices and not be worried about losing any. The app does unfortunately use US-English spelling (so you have to be careful of the autocorrect) and we did have one or two circumstances where the default click-and-hold options built into the Oppo R7 we tested it on, conflicted with the Monospace editing options. Other than that, it's an elegant and appealing app for note takers. Joel Burgess

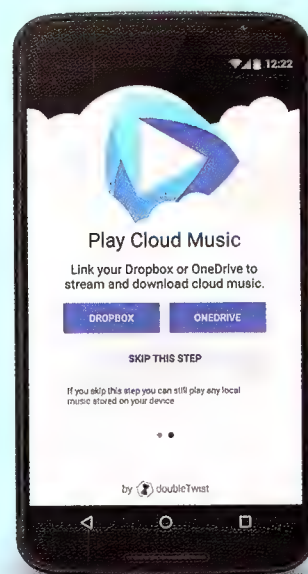


CloudPlayer

FREE (PREMIUM VERSION \$7.99) | WWW.DOUBLETWIST.COM



Kids these days are all like "my Spotify playlist has this" and "my Napster lets me stream that," but what if you're not interested in subscribing to some wallet-emptying service that doesn't even contain all the music you want to listen to? Still want to experience the wondrous cacophony of immediate aural delights that music streaming capability offers? What if you could stream your own cloud-uploaded music files, so you never have to fill your smart device up with MP3s again? Enter doubleTwist's new app, CloudPlayer. This handy app lets you access all of your music files from a range of cloud storage services, including Dropbox, OneDrive and Google Drive. You'll need to pay a one-time fee of \$7.99 to unlock streaming, Chromecast and AirPlay functionality, but it's worth it if you want to make your own all-encompassing music service, where licensing issues can't stop you from streaming The Beatles, Prince and everything else that's missing from Spotify and its ilk. Stephen Lambrechts





Windows Store » WIN PHONE 8

Video 360

An eye for an eye.
\$2.39 | TINYURL.COM/OHNTDOV



If you haven't had the opportunity to check out any of YouTube's 360 degree video archive yet, it's definitely something we'd recommend. Watching someone jump off a cliff in a wingsuit was already a riveting YouTube experience, but when you can pan around and look at the whole environment it makes you feel far more connected to the surroundings. Though you can do this through YouTube on the web and through native apps in Android and iOS, on Windows Phone you're going to have to look a bit further than the Microsoft-developed YouTube app. Video 360 was made by Webrox, the same company that developed Windows Phone YouTube client TubeCast. Not wanting to overlap products, all you can do with Video 360 is watch the spherical media that is available on YouTube. Although oddly, in order to search for said videos, you'll have to use TubeCast and then share them with Video 360 to watch them. For most, watching 360 videos on a Windows Phone won't be worth this app's \$2.39 price tag, but if you're interested in the area, this is the first Windows Phone app to let you do it. Joel Burgess

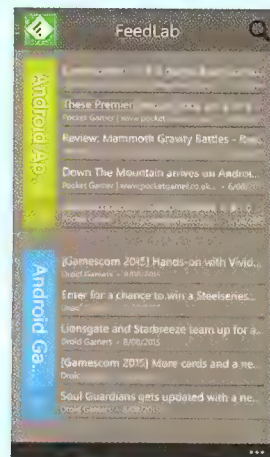


FeedLab

FREE | TINYURL.COM/O2828SP



One thing about having an operating system created by Microsoft is that there never seems to be a shortage of note-taking apps. Despite the plethora of options already available to Windows Phone owners, chances are you'll likely still want to take a look at this new offering from Microsoft's edgy DIY innovation centre, Microsoft Garage. Yes, on top of note-taking, InstaNote also has an audio recording feature, although this app's audio capture method is a little different to most. Instead of the usual start-and-stop recording, this app has a button that will capture the last 30 seconds of audio and run it through Bing, where all that audio will be transcribed into a succinct set of notes. The idea of having the most important chunks of a lecture, meeting or interview transcribed for you sounds like a dream come true, but admittedly, InstaNote is a little tricky to use at first and it doesn't always flawlessly transcribe notes. That said, in the worst-case scenario, you still have all the audio snippets of the most important info. Joel Burgess



Autodesk Pixlr

FREE | TINYURL.COM/NFPDS3M



Photo-editing apps may be common on Android and iOS smartphones, but other than Adobe Photoshop Express there are only a few decent options on Windows Phone. Pixlr has made a name via some impressive Android, iOS and web incarnations and now budding photographers using Microsoft's smartphone OS can finally join in. While this new app is reasonably basic at the moment, it does let you add post-shot effects to images in your smartphone's gallery and save them straight back into your camera roll, and further breaks up image manipulation into four main categories: adjustments, effects, overlays and borders, with each category having ample options to tweak your photos. In addition to saving directly to your phone, the app also lets you store pics on cloud services like Dropbox or OneNote, or share them through social media apps like Facebook. With a clean and easy to use interface, Autodesk Pixlr is a solid new photo editing app. Joel Burgess

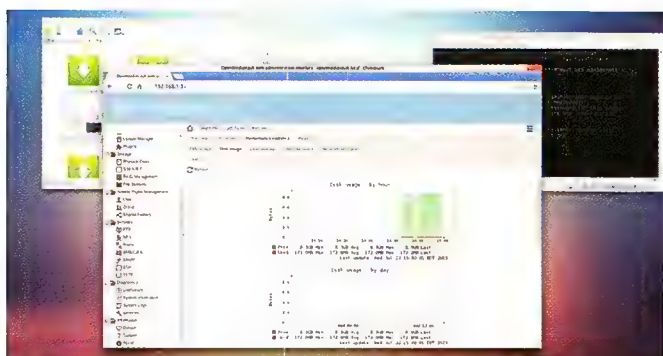




Open MediaVault

The open-source NAS distro for media lovers.

FREE | OPENMEDIAVAULT.ORG



Anyone who collects movies and pictures on their system hard drive should be thinking about upgrading to a NAS (network-attached storage) device, and OpenMediaVault's a dedicated open-source solution that tackles the problem easily. A specialised Linux distribution based on GNU/Debian, it features SSH, (S)FTP, SMB/CIFS, DAAP media server, rsync, BitTorrent client and all the components required for turning your device into a NAS. OpenMediaVault is generally for use in a home or small office setting, which means that you can install it onto an old PC and not necessarily a powerhouse. In fact, OpenMediaVault can even be run inside a virtual machine, as you forward an external storage device from the host system to the guest.

The deployed system is accessible from a traditional web interface, which looks like a neat welcome page, with a categories tree on the left and categorised content on the right. OpenMediaVault has a comprehensive set of storage control options, including RAID and SMART management, OwnCloud support, advanced user and group management and dozens of other handy controls.

The new OpenMediaVault 2.1 adds a new dashboard and widgets, an improved internal network interface back-end, VLAN and Wi-Fi support and various interface fixes. Also, the system now uses the browser local storage instead of cookies for caching user-made interface settings. All this is packed into the pre-built images for both x86 and x86_64 architectures, and each image weighs about 400MB.

The OpenMediaVault project has many intersections with FreeNAS, from which it was originally forked. However, it has distinct advantages, such as an add-on installer and updater (rather than global re-flashing in FreeNAS) and a more responsive web page. The latter is achieved by using the ExtJS and Ajax technologies, in contrast with Python+Django in FreeNAS. In real terms, this means that you don't have to reload the web page frequently as all data changes are applied instantly and live. **Alexander Tolstoy**

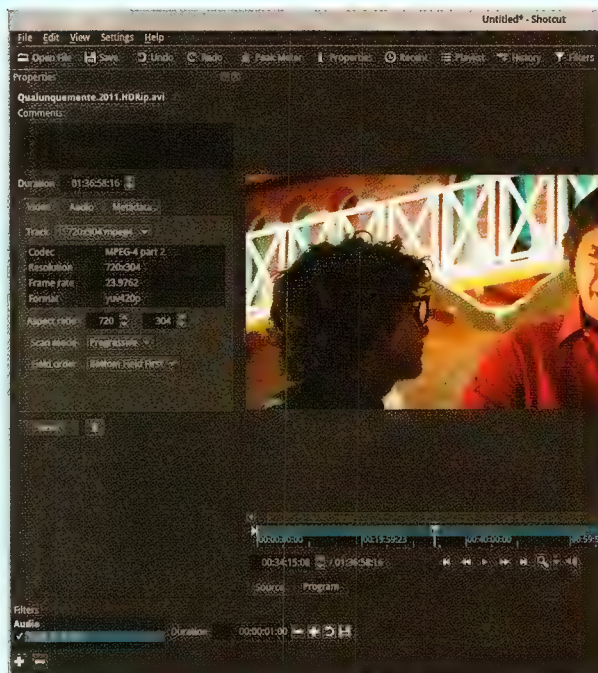
Shotcut

FREE | WWW.SHOTCUT.ORG

There are several video editors for Linux that use both GTK and Qt toolkits, but there's a noticeable trend in Qt-based apps that are more advanced and deliver many pro-grade features. The most well-established editor is perhaps Kdenlive, but this month we're putting the spotlight on another Qt-based video editor, Shotcut. This is a modular dark-themed application built with MLT (Media Lovin' Toolkit, used for Kdenlive and Openshot as well) and an FFmpeg back-end.

Shotcut has a vast number of panels and toolbars to the extent that the main area with its frames and timeline occupies less space than usual, which is as intended. Shotcut was started in 2012 aimed at achieving the simplicity of Kino (RIP, www.kinodv.org). Shotcut features many goodies, such as live editing (no import required), OpenGL GPU-based image processing, screen and webcam capture, network stream playback (HTTP, HLS, RTMP, RTSP, MMS, UDP) and many more, though most of the features can also be found in its competitors. However, Dan Dennedy, the main Shotcut developer, points out that his application is more stable and requires less assumed knowledge than the likes of Kdenlive.

Shotcut also maintains high development speed with many cool new features in each release. For instance, version 15.07 brings 4K UHD resolution support, five new filters for imitating old film, a new equaliser and audio filters, better H.264 encoding (with variable bitrate by default) and copy-paste support for the timeline. The editor is really worth trying out, which is quite easy to do thanks to Dennedy, who hates the repository-based approach of packaging Shotcut for specific Linux distros. Instead, there's a couple of static builds in TAR.BZ2 format, available from the project's website. No installation is required, as you just untar the archive and run the application. **Alexander Tolstoy**



WIRELESS CHARGING IS A MUST-HAVE FOR SMARTPHONES • BUY ON TICK OR TOCK? • IPS DISPLAYS ARE ALWAYS BETTER • OVERCHARGING KILLS YOUR SMARTPHONE BATTERY • DISCHARGE YOUR SMARTPHONE BEFORE CHARGING • FLASH STORAGE RETAINS DATA FOREVER • HIGH-SPEED RAM ADDS SIGNIFICANT PC SPEED • SET WINDOWS 10 FOR FASTER BOOTING! • ALL USB CHARGERS WITH AN AU PLUG ARE SAFE • ALL SAME-TYPE SSDS HAVE EQUAL ENDURANCE • EXPENSIVE HDMI CABLES WORK BETTER • IT'S OK TO LET YOUR COMPUTER RUN HOT • ONLINE PRIVACY AGREEMENTS ARE FOR YOUR BENEFIT



THE TRUTH REVEALED

TECH MYTHS BUSTED!

SOME THINGS WE THINK WE KNOW AREN'T ALWAYS SO. DARREN YATES
BUSTS SOME POPULAR AND LESSER-KNOWN TECH MYTHS.

As geeks, we never stop learning – if you do, you're either too old, or you're dead. But even when we think we know something, there's a good chance what we think we know isn't really what we know, you know? It's often good to revisit and question the things we have stored away in our memory banks to find out whether they're still true, or if they ever were actually true in the first place.

Some myths, such as Apple computers don't get viruses, are pretty obvious, so we've avoided them and instead looked at some of what might be lesser-known but still important tech myths to be aware of, things as diverse as cheap USB chargers and RAM speed. Now you might not agree with some of the things we've come up with. If not, the 'APC flame bar and grill' is always open.

Because technology is generally, well, technical, along with the fact that there's just so damn much of it, it's easy for myths to form, grow and take on a life of their own. For example, Moore's Law, which is often quoted as 'the density of silicon chips will double every 18 months', isn't actually Moore's Law. Former Intel CEO Gordon Moore, to whom the law is attributed, told CNet he said it was 'every two years' and that the '18 months' came from former Intel executive David House (tinyurl.com/obqb4jz).

Tech myths are hard to avoid, meaning it's always good to challenge what we think we know because, to state the bleeding obvious, technology – it changes. You know?

IPS displays are always better

MYTH

Well, we wouldn't take this one to the bank! It actually depends on how you spell your tech. Personally, I love IPS (in-plane switching) panels. I love the deeper, richer colours, I love the beautifully wide viewing angles. But IPS is as much a trademark as it is a monitor category – meaning it's not the only option. Samsung's PLS (plane-to-line switching) is a variation on a similar theme, as is AUO's AHVA (Advanced Hyper Viewing Angle).

Even so, the IPS category itself isn't the best at everything – no monitor tech is. They all have something they don't do as well as other alternatives. For example, IPS panels generally have slower response times that don't suit gaming. Fast TN (twisted nematic) panels don't typically deliver the best colour accuracy. VA (vertical alignment) panels try to beat both, but mostly only take a middle ground.

As for OLED (organic light-emitting diode)? There are issues here with lifespan, showing up as changes in how the individual red, green and blue OLEDs (particularly blue) degrade over time, so it's not perfect either.

The most practical advice we can give is try to see a monitor deliver on the apps you're going to use before you buy it. Sure, that's easier said than done in many instances, but saying IPS is always better makes as much sense as saying cheese is always better than chocolate – it depends on what you're doing with it.

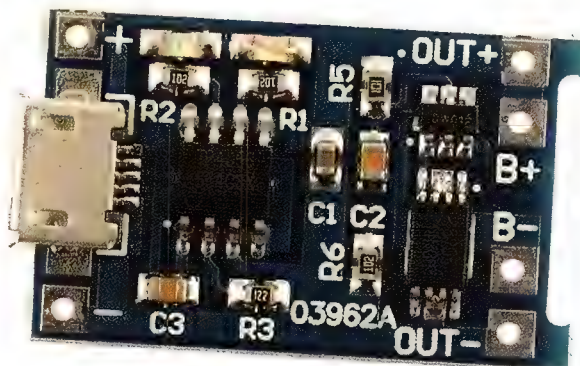
Overcharging kills your smartphone battery

MYTH

Actually, this one is true – overcharging a smartphone battery will kill it. Either it will pop the cell in a controlled (burst) or uncontrolled (explode/flames) manner. But for all that, it's really difficult to overcharge a smartphone battery, making this a dud myth – your phone just won't allow it.

Exploding smartphone batteries are not great for a phone maker's profitability – neither are the lawsuits that would typically follow – so all smartphones incorporate battery management circuitry that not only stops your phone overcharging the battery, it also ensures that it doesn't over-discharge the battery either. Lithium-ion batteries are terrific, but they're notoriously fussy and if you discharge one beyond its 'point of no return', you'll kill it. So, the circuitry is designed to keep it happy. The only way we can see that you could attempt to overcharge a phone battery is to have the phone powered off, remove the USB charge cable once the phone says the battery is charged and plug it straight back in again to try and trigger the phone to start charging again. But chances are you'd have to do this that many times to cause any real problem, you'd break the microUSB connector first.

And if someone tells you leaving your phone on charge overnight will kill the battery, you can tell them that's rubbish, too, for the same reason.



"I don't often find myself agreeing with Apple. But on the topic of wireless charging, I totally get where Apple was coming from."



Wireless charging is a must-have for smartphones



I don't often find myself agreeing with Apple. But on the topic of wireless charging, I totally get where Apple Senior Vice President Phil Schiller was coming from (tinyurl.com/8d4cg4w) – for consumer electronic devices like smartphones and tablets, what's the point of wireless charging? Does it save cables? No – as Schiller said, you still have to have a baseplate and that has to connect to power somewhere via cabling. Does it charge faster? No – inductive charging doesn't charge as fast as a direct connection (but soon will, according to new claims).

Is it more efficient? Again, no – wireless charging creates losses,

including as heat in the wire coils, heat that won't do the phone battery any good and losses you don't get with direct-wired charging. Further, university tests show the real-world efficiency of wireless charging tech available aimed at smartphones is only around the 65-70% mark at best (tinyurl.com/nnz7zdb) – that means you're spending 40% more electricity to charge your device with this tech than using a cable. Multiply that 65-70% efficiency by a billion smartphones charging every day and that's a heck of a lot of extra energy we'd have to generate. At a time when almost everyone is looking at reducing energy consumption, why are we now happy to drop from a comparative 100% to 70% efficiency to accommodate wireless charging?

Is it cheaper? Nope – wireless charging tech will always cost more

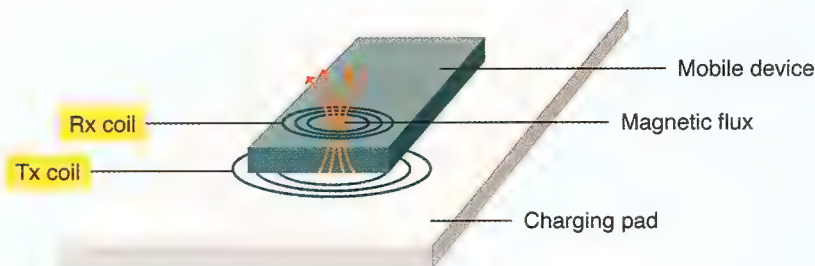
than 1.8-metres of USB charge cable, but the 70% efficiency means it'll also cost more in electricity, unless serious improvements are found.

I'm all for convenience and there are applications where wireless charging will rock – medical implants, for example, and sealed gear that must live in harsh outdoor locations where connectors are an open-house invitation for dust. It's also getting serious notice from electric carmakers. But for now, do we really need to use up 40% more energy to save 10 seconds hooking up a USB charge cable?

HOW IT WORKS

Wireless or inductive charging uses a concept originally discovered by Michael Faraday about 200 years ago, that if you pulse an electric current through one of two windings of wire wound around a ring of iron, the changing electromagnetic field created 'induces' an electric current in the second winding. Faraday didn't know it at the time, but he had discovered the basic principle of the transformer and without it, we'd still be in the dark ages, literally (there'd be no power grid, for starters).

Inductive charging works on this principle, except the ring of iron is replaced by literally nothing – air. The clever concept of 'resonant inductive coupling' is similar, too, but runs at higher frequencies. It works a bit like an AM-band radio receiver picking up broadcast transmissions via a 'tuned circuit'. It can increase the 'coupling' distance (distance between power



Energy is transmitted from the Tx coil to the Rx coil by the electromagnetic induction between them.

transmitter and phone receiver), but there are questions about whether its efficiency matches inductive charging at smartphone power levels.

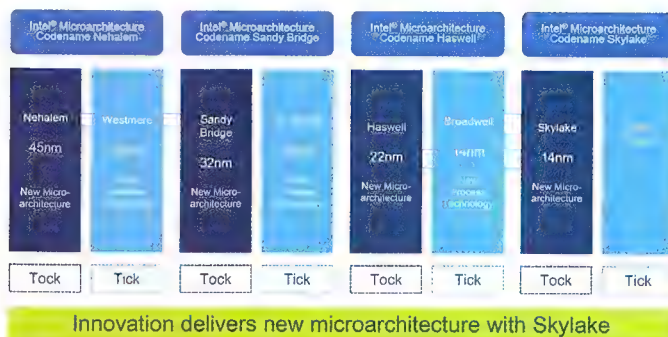
Either way, wireless charging is less efficient than direct-connect, through that loss in energy in the coupling. Since the efficiency is lower, you either have to pump in more energy to match the charge speed of direct cabling or charge at a slower rate. If you don't align the coils in your phone and the charge plate just right, efficiency drops further and charging takes longer again (although multiple coils and clever new sensing tech aim to help). But none of this is helped by two competing standards – Alliance for Wireless Power (A4WP) and the Wireless Power Consortium (WPC).

In its favour, wireless charging is still a relatively new technology and university research has managed to hit 85% efficiency (tinyurl.com/pqotpf). However, it's a long way from the lab to the lounge room – and even further to match cable-charging. The WPC is currently updating its Qi standard to increase charge speed, claiming to now match wired charging. But we suspect it'll still be at around 70% efficiency.

Wireless charging is interesting tech, but for smartphones and tablets, it's not there yet.

Tick-Tock Development Model:

Sustained Microprocessor Leadership



PCs: Buy on tick or tock?

CPU design is a well-oiled machine, and a hugely expensive one at that. So much so, that chip giant Intel likes to have two runs at each new level of transistor miniaturisation – the first of those runs (the 'tick') is the launch of a new smaller transistor manufacturing size; the second (the 'tock') adds new features or 'micro-architecture' to the core(s).

But what does it mean in practice when you head online to spec up a new machine? New chips of the 'tick' cycle, such as 'Ivy Bridge' and 'Broadwell', get the first crack at the smaller die/transistor size and generally deliver better power consumption, whereas 'tock'-cycle chips, like Haswell and the up-coming Skylake, get the benefit of added performance.

So, if you're buying or building a new desktop, the 'tock' cycle makes more sense – it's the more mature tech and delivers extra speed (although sometimes not as noticeable). But if you're keen on a new notebook, the 'tick' iteration is where you'll likely see more battery life gains. The only caveat on this is that the CPU isn't always the chief power-guzzler in a notebook – you can't forget the LCD panel and its backlight.

Still, in general, if its performance you're after, buy on the 'tock', but if you value reduced power consumption more, buy the 'tick'.

"Intel likes to have two runs at each new level of miniaturisation."



MYTH

High-speed RAM adds significant PC speed

Maybe it does in some parallel universe, but not here. We've looked at this a number of times in APC Labs over the years and the evidence to support higher-speed RAM adding significant sizzle to your system speed just never stacks up.

Yes, technically, choosing DDR3-1866 or even DDR3-2133 RAM – if your motherboard can use it – will run your system faster than stodgy old DDR3-1333 or 1600 memory. But the actual gains are never more than a few percentage points and for the extra money you spend, you're almost always better off putting that money towards the next rung of the CPU or graphics card ladder, where you're more likely to see greater performance gains.

Flash storage retains data forever

MYTH

With flash memory card prices so cheap, a lot of people think it's fine to just use them as permanent storage for precious photos and whatever — basically, using them as a ready-made backup as soon as the card comes out of the USB port or camera, because that data stays there forever. Well, you wouldn't guarantee it — and neither do flash manufacturers. It turns out there are two things flash memory cells don't like — they don't like being written to and they definitely don't like heat.

Two companies that deal a lot in flash — Texas Instruments and Macronix — have performed accelerated testing on flash memory and found that the more you use a flash device, the less time the flash memory cells will retain data. However, if the flash device is kept at high temperatures, the data retention time can drop off a cliff. This data retention lifetime graph from a Macronix Application Note (tinyurl.com/otumld6) shows brand-new flash memory cells (less than 10 program/



erase or P/E cycles of use) will hold data for 100,000 years at 25°C. Crank that up to 60-degrees, though, and it's just 1,000 years.

Now before you laugh too hard, these are accelerated tests, so go with us on this for a bit — take flash memory flogged up to 100,000 P/E cycles and it'll retain data for around 100 years if kept at 25°C. But push that flash cell to

60°C and it'll struggle to retain data for just a single year. Push 80°C and you might get five weeks.

Flash maker Spansion carried out similar tests — data retention on brand-new flash is rated at 20 years at 55°C. After 1000 P/E cycles at that temp, it's 10 years. By the time 10,000 cycles have been run and won, you're down to one year (tinyurl.com/o7fy7cf).

Now chances are pretty good you won't be taking photos on a clapped-out flash card and storing it in 80-degree temps. But the Internet of Things (IoT) is bringing flash memory into many industrial areas with temperatures you can't guarantee will hover at a comfortable 25°C. That's where high-quality industrial-grade cards come in. Interestingly, Panasonic rates non-industrial SD cards good for only 250 P/E cycles and single-level cell (SLC) industrial-grade cards for 60,000 cycles (tinyurl.com/q9bfkww), but still at no more than 85°C.

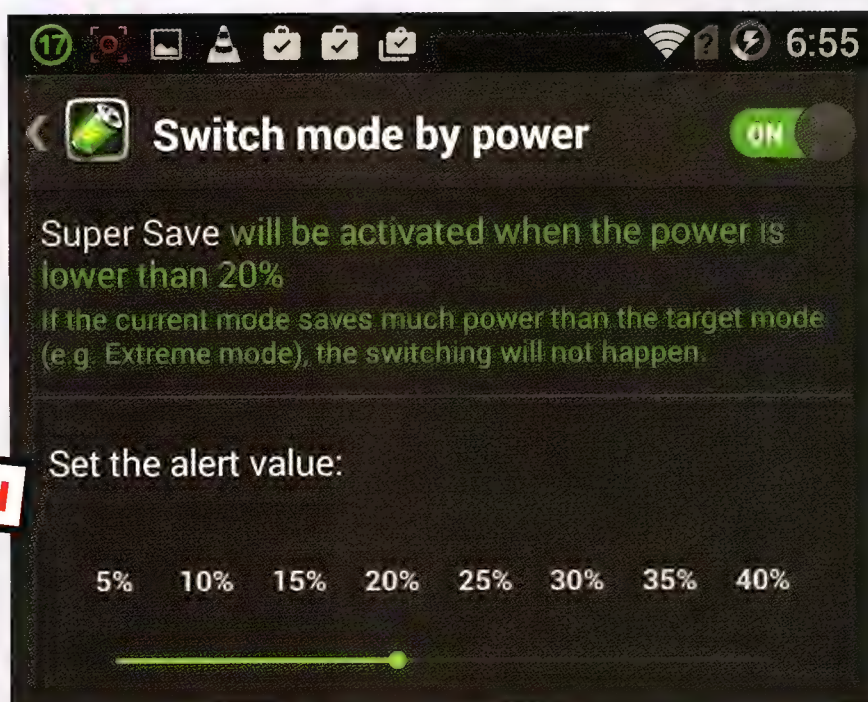
So, yes, flash memory is robust — but it ain't bulletproof.

"Older NiMH batteries do have some memory effect, but it's not a real issue today."

Discharge your smartphone before charging

MYTH

If you hear this one, don't just walk away, run. About 20 years ago when rechargeable batteries were mostly horrible Nickel-Cadmium types, this was totally true. Those batteries suffered from a problem called 'memory effect', which meant the level you regularly discharged them to would become the new 'discharged' level. For example, discharge 'Nicads' to 50% often enough and the 50% mark would become the new 'dead-flat', losing you half the battery capacity in the process. Nicads don't have the same capacity as newer Nickel-Metal-Hydrate (NiMH) cells



either, so it was a real problem. Older NiMH batteries do have some memory effect, but it's not a real issue today.

Not that it matters — every smartphone uses Lithium-based battery tech, so by fully discharging it first, you're only likely to do the battery more harm than good. The problem is, Lithium-ion batteries are often good for as little as 500 full

charge-discharge cycles, half of NiMH's nominal 1,000 cycles. But tests have shown that if you discharge a Lithium-ion battery to only half-empty, you can extend the total life of the battery up to 1,500 cycles or so (tinyurl.com/2349lq2).

MYTH

Set Windows 10 for faster booting!

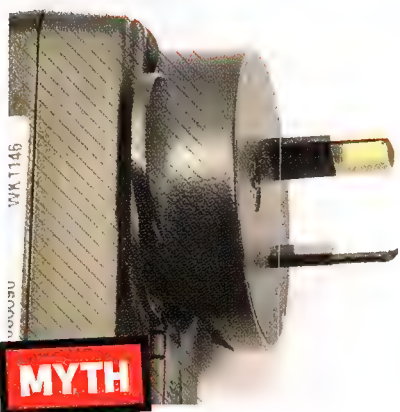
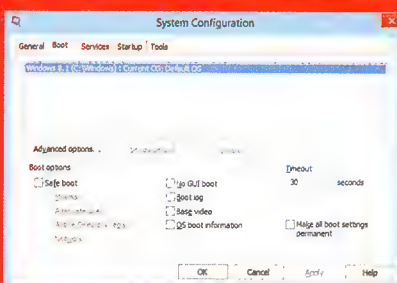
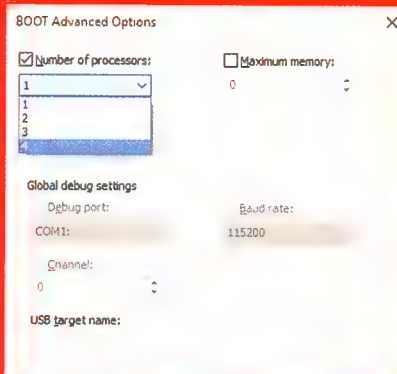
Now to be honest, we haven't actually heard anyone call this one out yet, so we're calling this a pre-emptive strike. One built-in Windows tool that sometimes gets users into trouble is `msconfig`. It's a great little utility for tweaking Windows boot, services and startup options. If you're running Windows 10, fire up `msconfig` (type `msconfig` on the run/search box in Start and hit Enter), click on the Boot tab, then press the Advanced Options button. You'll see a 'number of processors' checkbox and a listbox selected. Check that box, the list becomes live, scroll down, set the maximum number of processors (CPU cores available) and bingo — you'll get Windows 10 booting up considerably faster.

The only problem is it's a steaming clunkpot of lies. This is a variation on a myth that originated back in the days of Windows Vista when this option first appeared. It's been a feature of `msconfig` in every Windows release since, but here's what Microsoft says about it:

Number of processors. Limits the number of processors used on a multiprocessor system. If the check box is selected, the system boots using only the number of processors in the drop-down list (tinyurl.com/ksj6auh).

Yep, it's just a way to manually limit the number of CPU cores Windows uses on boot. Think about it — Microsoft's not dopey. It's not about to limit boot performance and not use every CPU core available. Misreading these software twiddles can do far more harm to system performance on boot-up than you think.

Our tip is just leave this one alone. If you want Windows 10 to boot faster, try the old-school options of a faster CPU or using a solid-state drive.



All USB chargers with an AU plug are safe

You probably already know that just adding a plug converter to a power brick of US-origin may prove problematic because of the AC voltage differences between the US and Australia (110VAC in the US and 240VAC here). So that suggests any power brick with an Australian angled plug on the end has to be safe, right?

Unfortunately, no. This is particularly true if you're tempted to buy the dirt-cheap AU-plugged USB chargers in some overseas online stores. They're often called 'fake' chargers, but it's a misnomer — even the 'fake' chargers work, that's not the problem. All electrical power adapters sold in Australia should be designed to pass our 'C-tick' electrical standards that ensure the product you're buying is safe for use. There are cheap USB chargers with AU plugs available

online outside Australia that don't bother with C-tick. All of these devices use clever electronics to convert the 240VAC mains voltage into the 5VDC USB standard that will charge your device, but they don't all afford the protection of heavier old-school, transformer-based power bricks.

To test this out, I purchased a couple of budget USB power chargers online from overseas, specifically to pull apart and see how they're made. What I saw will ensure they are never used in my home. When you see light-gauge hookup wire soldered directly to the plug pins with just a couple of dollops of solder and the other ends of those wires loosely soldered into the circuit board, you're looking at an accident waiting to happen. One of those wires only has to let go, touch some other part of the circuit board and you could have up to 240VAC power running right up your USB cable.

So our tip is this — be very careful when buying a cheap USB charger from

a \$2 discount shop and do not purchase Australian-plugged mains power adapters online from overseas. If you buy a gadget online from overseas with its own cheap AC power adapter, consider replacing it immediately with a locally-sourced approved alternative from Jaycar Electronics, Dick Smith, Altronics or similar, ensuring the voltage, current and plug polarity ratings are the same.

I buy technology gear online, but any USB power adapters get noted for the specs and tossed in a box marked 'do not use'. You can always find an alternative power source — the risks of using cheap, non-standard power adapters from overseas are never worth it. Oh, and if you're tempted to take a US-origin power brick and bend the AC plug pins with a pair of pliers to make it fit our mains sockets (don't laugh, I've seen this), consider your geek license revoked.



MYTH All same-type SSDs have equal endurance

This might surprise you, but the answer is no, they don't. Buy a hard drive and you get a hard drive — it writes data to the disk platter(s) and you reasonably expect that if you buy a drive of any capacity from the same family, they'll all stand the chance of lasting roughly the same amount of time.

The same isn't true for Solid State Drives — buy a 64GB SSD and it'll potentially only last half as long as a 128GB model, which will last only half as long as a 256GB model and so on.

Why? You know doubt know that every time you write data to an SSD memory cell, you're slowly killing it — they only have so many program/erase (P/E) cycles, usually less than 5,000 for most consumer models. So to ensure maximum lifespan, drive manufacturers employ a technique called 'static wear-leveling', which aims to spread the data love around and ensure that no particular memory cell gets overworked more than any other.

Now if you have a 128GB SSD, you have twice as many cells available as a 64GB SSD to spread the wear, meaning, when writing the same amount of data per day, the 128GB SSD will run twice as long (Fujitsu white paper, pages 14 & 15, tinyurl.com/oboedvs). Getting more capacity is one way to extend endurance.



"Getting more capacity is one way to extend endurance."

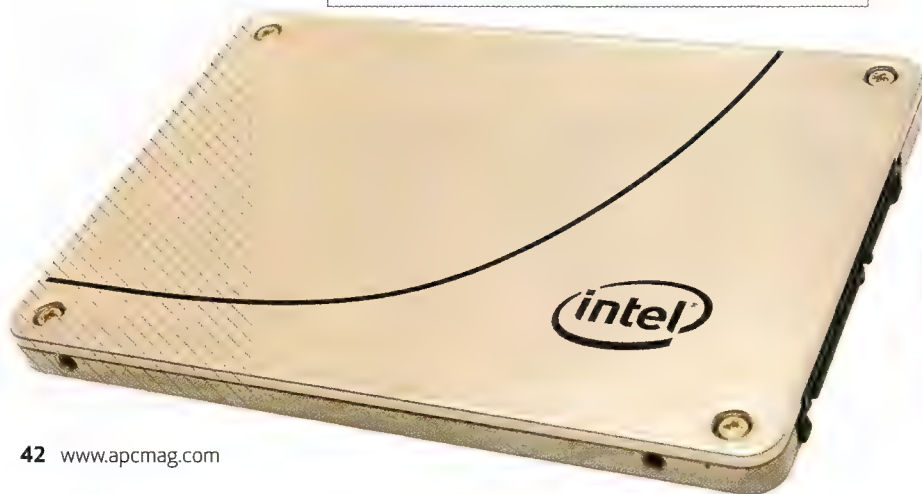
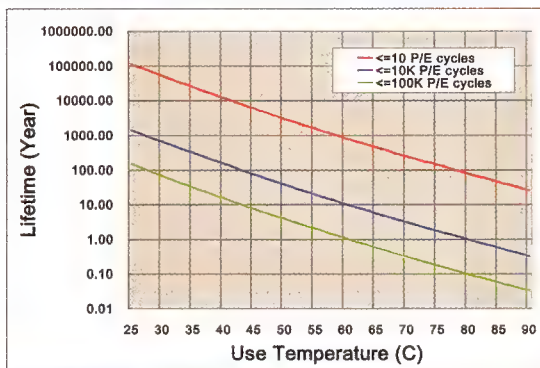
MYTH

It's OK to let your computer run hot

I read a post recently saying essentially this and struggled to figure it out for a while. The upshot was that computers can run hotter than we normally let them, but hey, that's a good thing because 'the hotter the CPU is allowed to be, the more freedom it has to run at a higher clock speed'. Maybe, but it's never really good to let a computer run hot — and for a laptop, 'hot' is anything over 40°C. The reason? Heat kills batteries — whether it's your smartphone, notebook or tablet. As we've seen already, lithium-ion batteries don't like heat, so the hotter you run your portable device, the more you're stressing the battery and that'll mean fewer charge cycles and less run-time per charge. According to one source, running at 40°C and full-charge can knock the real capacity down to just 65% in just three months (tinyurl.com/2349lq2).

A desktop CPU can run up to 70°C at peak times without significant damage, but a decent cooler should never allow a CPU to get that hot, so there's no real need to let it happen.

Figure 3. Data Retention Lifetime after various P/E Cycles at T>= 55°C





MYTH

Expensive HDMI cables work better

Well, that depends highly on your definition of 'work'. If we're talking about getting audio and video from your media player to your TV over short distances, you won't likely notice any difference between the \$3 cable you buy on eBay and the \$200 platinum-plated oxygen-free copper premium offering. As others have said, the signal is digital, so provided there is continuity in all connections of the cable, it should work.

But there is one caveat I've found — that's because I purchased one of these cheap cables and pulled it apart to see how it worked. The way you make a cable cheaper is put less into it — some ultra-cheap HDMI cables won't give you all the internal connections.

An HDMI connector has 19 pins in total in two rows, ten on the top and nine underneath. However, depending on the HDMI standard you're working to, not all of the pins are strictly necessary and you don't need all of the pins to transmit audio/video. The cable I purchased had only 13 of those 19 pins wired up, but for the most part, the cable worked, delivering correct-spec video and sound.

So what was missing? Firstly, the CEC line wasn't connected. CEC stands for Consumer Electronics Control — it's a one-wire communication/control system that allows you to use your TV remote to turn off your DVD player at the same time. For HDMI versions 1.3c and older, there's also a 'reserved' pin that doesn't do anything and unless you have HDMI v1.4 gear, you won't notice it missing, so it wasn't there either.

To transmit such high-speed signals reliably over longer distances without interference, HDMI uses a differential

signal system called TMDS (Transition Minimising Differential Signaling) that sends the digital signal on one wire and its mirror-opposite on another. Now there are four digital signals to be transmitted using TMDS — a clock signal plus three data signals. These four plus their mirrors were all present on the cheap cable, but what was missing was the shield wire for each signal — the manufacturer decided TMDS didn't need individual shield wiring over the short distance, so those four wires were missing, too.

Provided you don't need full CEC-remote control and you use cable lengths of no more than two metres, this budget cable worked beautifully — but for longer runs and full functionality, this is where you do need to spend a bit more and ensure you pick up an HDMI v1.4 cable to get all of those pins connected through. But not \$200 worth.

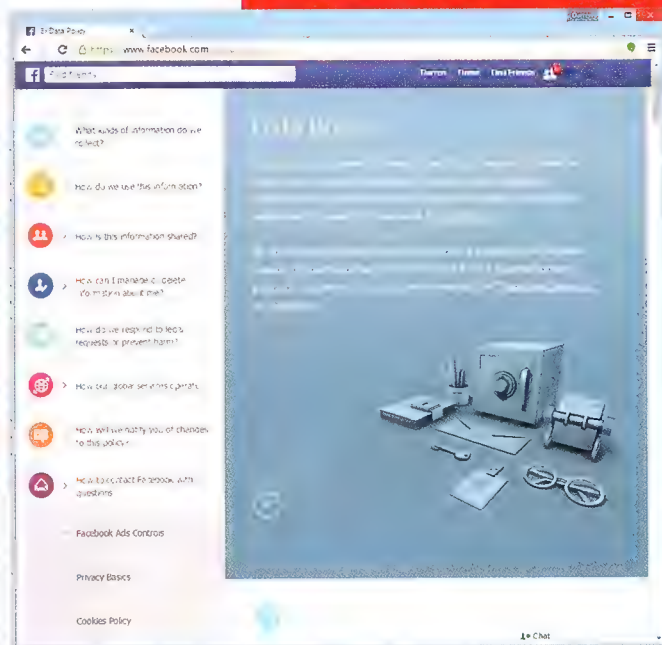
MYTH

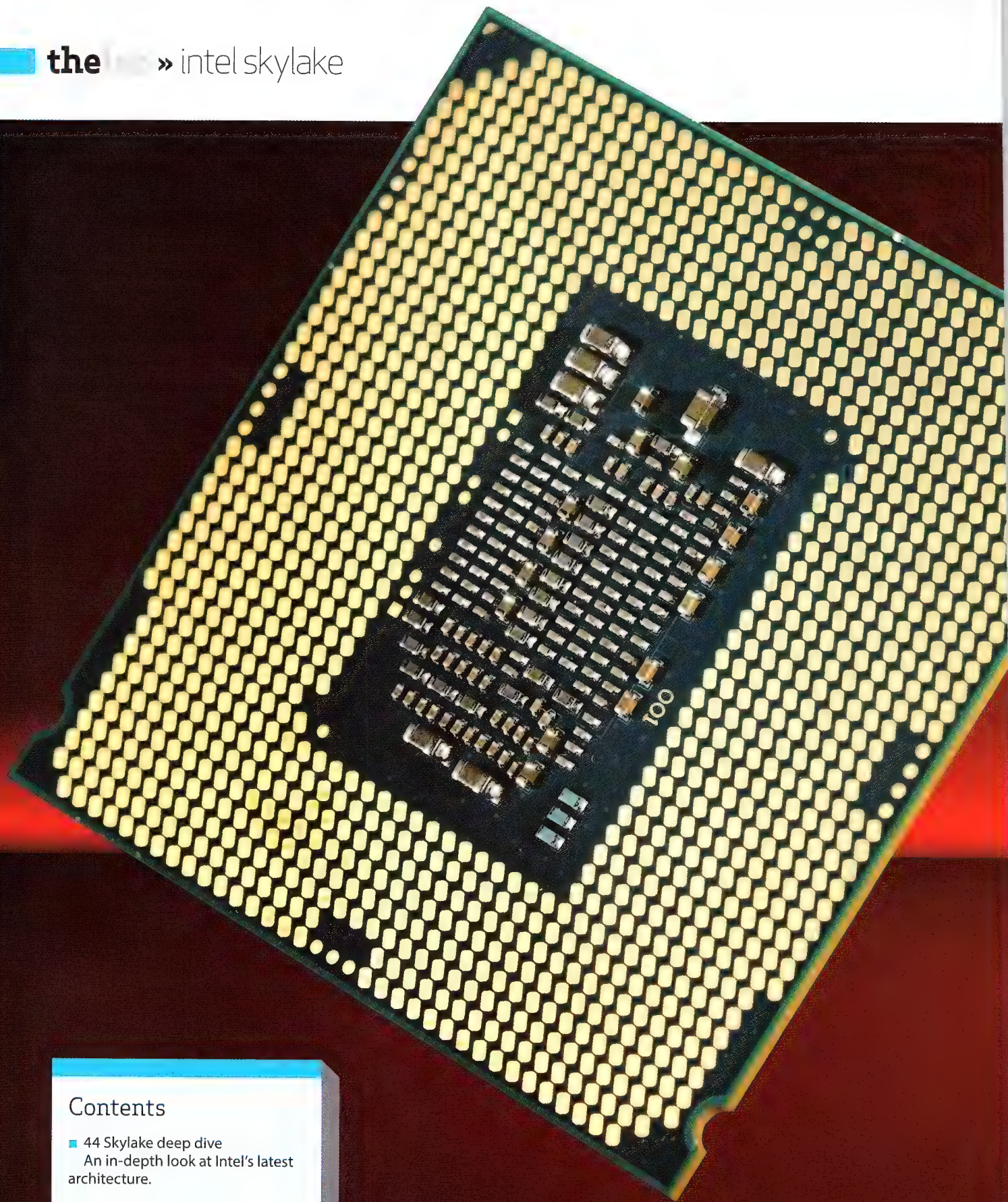
Online privacy agreements are for your benefit

Well, we had to finish this off with a laugh, but sadly, there must still be folk who think this true, that your privacy is paramount to every company online. Privacy is very much of relative term these days — it depends on who you're actually wanting privacy from.

Take this little test — when was the last time you signed up to an online service after reading the company's privacy policy statement? Actually, let's make it simpler — when did you last read a privacy policy statement? For example, did you know Facebook's privacy policy permits them to conduct 'research' on data it gathers from you (www.facebook.com/about/privacy)? Did you know Facebook manipulated the newsfeeds of nearly 700,000 users in early 2012 to see the effects on users' emotions (tinyurl.com/mm8twwy)? If you're a science/psychology geek, it sounds pretty interesting — but not if you're one of the 700,000.

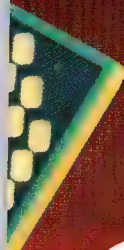
There's a growing sense that when it comes to keeping our privacy, particularly against large online companies, the horse has well and truly bolted. University of New South Wales professor of law and information systems, Graham Greenleaf, last year said the strengthening of privacy laws worldwide was being 'overshadowed' by the ability of US-based companies to suck up personal data and use it with little restriction (tinyurl.com/nnodomg). It should at least stop and make us think for a bit. ■





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SKYLAKE

deep dive

Intel's latest architecture is finally here, so Zak Storey got investigating.

Well, here you have it folks. Skylake hath cometh to the people, and with it comes the absolute pinnacle of Intel's micro-processing technology. Let's just forget about Broadwell. Its short life time has been invaluable to us PC enthusiasts, but alas, it was never meant to be.

Taking us from that blasted 22nm architecture down to 14nm was an incredible feat. But it was too little, too late. Ultimately, the little chip paid the price, doomed to retire to an early death. An unfortunate victim of its own architecture's difficult production methods.

Broadwell's glorious sacrifice, however, has given us one phenomenal gem – Skylake. If the X99 chipset and

Haswell-E was the premium-grade reboot that PC enthusiasts needed, it's safe to say that Z170 and Skylake is about to do the same for the rest of us lowly four-core lovers. And let's face it, we've sorely needed it.

The last three generations of Intel CPUs have hardly seen a vast improvement over the original Sandy Bridge chips, and it's about time we were given CPUs that mopped the floor with that dusty old dog. Yes, Intel's cores may generally run rings around the competition when it comes to compute performance, but a 5% performance increase and 10% power reduction, year after year, just isn't exciting enough to warrant tattooing the Intel logo on the inside of our thighs. Not just yet.

Regardless of how it likes to name its early morning glow chipsets, Intel needs to knock this one out of the park. And although it's pretty much cemented itself in the world of enthusiast-grade CPUs, another 5% performance boost just isn't that interesting, especially when most games currently struggle to utilise anything more than four cores anyway. Hell, we'd still recommend the i5-2500K if it was still available for sale.

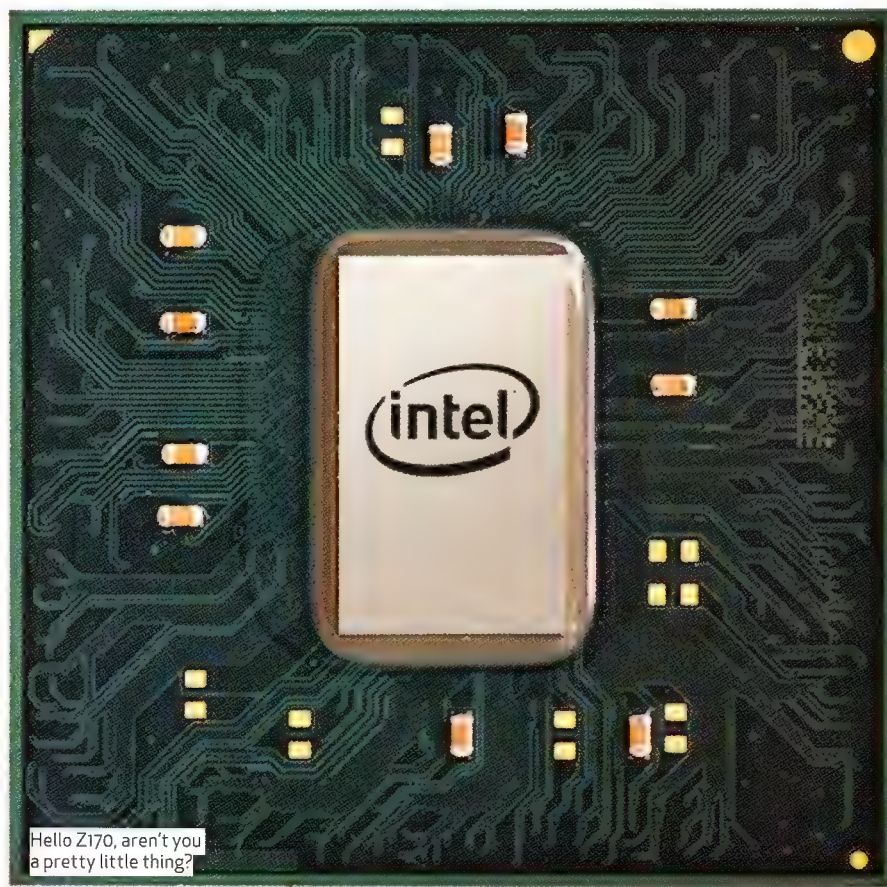
So what was it that kept Intel behind for so long? What do these chips represent to us? And what shiny new features will it bring to the table? Read on to find out what we discover in our in-depth report.

Skylake and the Z170 Chipset

Let's start with the basics. At this point, we have the Intel Core i5-6600K and the Core i7-6700K – the premium overclocking CPUs for the enthusiast users. These are the flagship models of Intel's consumer brand. Processors that, by their very nature, are designed to be pushed to the limits in the hunt for number-crunching, benchmark-rendering, overclocking perfection.

But what does Skylake bring to the table that Haswell didn't? Well, a 14nm processor for starters. Similar to the now-redundant Broadwell, yet a lot more promising. Intel has dropped the FIVR (Fully Integrated Voltage Regulator) from the CPU die and left voltage control entirely down to the motherboard manufacturers. This allows aftermarket partners to control how they supply power to each individual voltage controller located onboard the chip. What's exciting about this is how much variance we may start to see in the motherboard market once again. It's an area where, for a long time, it's been very difficult to differentiate between or even justify the cost of a \$400 board over a \$200 one. It might make choosing your motherboard about more than just buying the prettiest one for your budget. And that's fantastic, especially for competition's sake.

On top of all this loveliness, the Z170



SPECIFICATIONS

	INTEL CORE I7-6700K	INTEL CORE I7-4790K
LITHOGRAPHY	14NM	22NM
FREQUENCY	4GHZ (TURBO TO 4.2GHZ)	4GHZ (TURBO TO 4.4GHZ)
CORES/THREADS	4/8	4/8
CACHE	8MB	8MB
TDP	91W	88W
DDR SUPPORT	DDR4/DDR3L - 64GB MAX	DDR3/DDR3L - 32GB MAX
PCI-E CONFIGURATION	1X 16, 2X 8, 1X 8, 2X 4 - GEN3	1X 16, 2X 8, 1X 8, 2X 4 - GEN3
INTEL GRAPHICS	INTEL HD GRAPHICS 530	INTEL HD GRAPHICS 4600

"But what does Skylake bring to the table that Haswell didn't? Well, a 14nm processor for starters."

chipset has a vastly expanded array of storage options – including Intel's new U.2 PCI Express connector, an additional 12 PCIe lanes to allow greater performance when running NVMe, and PCIe M.2 drives (an upgrade from gen2 to gen3). There's also continued support for six SATA 6Gb/s devices, up to 10 USB 3.0 ports and 14 USB 2.0 ports. Rather surprisingly, however, there isn't any native support for USB 3.1 (both Type A and Type C). Intel has stated that it's banking on

Thunderbolt 3 being the more appealing solution to this particular platform. Although this seems a little short-sighted going forwards, only time will tell whether that will hold true or not. Who knows, maybe 3D Xpoint memory sticks will be powered by Thunderbolt and Intel will become our silicon overlord.

MEMORY MUSCLE

But the biggest and most exciting feature by far is the support for DDR4 RAM, the final advancement beyond

the limited 2,400MHz DDR3 band. Z170 motherboards will support up to 64GB of memory, from 2,400MHz all the way up to 4,000MHz and beyond, advancing the ageing platform far past that of its Broadwell and Haswell cousins.

But don't fret if DDR4 prices are still a little too steep, and you have a few DDR3L RAM sticks kicking about, Skylake is backwards compatible. Albeit only with the low-voltage economy version, as opposed to the last platform's DDR3 offerings. That means that if you'd rather just use a DDR3L-enabled motherboard, you can do just that. But saying that, these boards do seem to be few and far between. The only manufacturer we know of that has boards with this feature for the foreseeable future is Biostar, a company that didn't exactly score very highly in its last review here

If you're dipping into the funds to build a new rig, you really should be looking at DDR4. Prices have dropped by roughly half since they were launched in October last year, which means you're only paying around \$40 extra for the same capacity of RAM at a far higher frequency than you once were.

Still not interested? Do you consider yourself a bit of a speed freak, but memory just doesn't float your boat? Well, ladies and gents, we have one last nugget of juicy information for you – that's the inclusion of PCIe Raid 0, 1 and 5 support, allowing end users to RAID multiple NVMe drives together.

This has the potential to increase transfer read and write speeds all the way up to 3,500MB/s and beyond, approximately six times faster than your traditional SSD.

A new architecture

Skylake's new architecture has been painstakingly woven from Intel's manufacturing plants and engineering genius. Having to drop Broadwell, even just to make its production deadlines, Skylake is the first widely available 14nm CPU microarchitecture.

It's a chip that's situated in the brand-spanking new 1151 socket (yes, one whole extra pin), alongside the Z170 chipset. Although not the consumer's first access to a 14nm chip, it'll be the most commonly sought-after processor line going forward, the go-to buy for us PC

SPECIFICATIONS		
	Z170 CHIPSET	Z97 CHIPSET
PCIe LANES	20 LANES GEN3.0	8 LANES GEN2.0
SATA CONNECTIVITY	6X SATA PORTS / ESATA	6X SATA PORTS / ESATA
USB SUPPORT	10X USB 3.0 / 14X USB 2.0	6X USB 3.0 / 8 USB 2.0
ETHERNET	10/100/1000 MAC	10/100/1000 MAC

silicon. Essentially, a wafer-thin slice of computing crystalline goodness, silicon provides the basis for what the CPU will become, before it's cut out and embedded into the CPU superstructure that we're all so familiar with. Utilising a 193nm ArF lithography (basically a high-powered laser), Intel has to etch in all of the details for each and every processor, from each transistor upwards, essentially crafting every detail that makes a CPU a CPU.

The difficulty lies in the lithography itself. The laser in its most minute form is 193nm wide. To put that into perspective, the width of a human hair is 75,000nm across. So, to get that tiny beam of light small enough to even create one single transistor, it's necessary to utilise a variety of different technologies and optics to split the beam into even more ridiculous molecular sizes without necessarily losing any of the additional power that comes from the original beam. The smaller you go, the more difficult it becomes to split the laser down further. Ultimately, this is why it's taken Intel so long to go from the 22nm die size to 14nm, and thus why Broadwell has had such a brief (and rather unexciting) shelf life. We can

only hope that this will not be the case for the 10nm chips.

KIT CRAZY

But alas, not all is lost. If it wasn't for Broadwell's sacrifice, we wouldn't have Skylake. Thankfully, it's here and on schedule, ensuring Intel's latest flagship dodged a similar fate. For release dates we can only speculate at this point, but rumour has it the full desktop lineup should be available by the end of this year, with mobile laptop processors making it to market by early 2016. Again, speculation and rumour on our part.

DDR4 memory is a crucial part of Intel's marketing strategy here. Although it's the next natural progression, the launch price was more than enough to put most people off their dinner. Fortunately, kits have been around since October 2014 and have slowly dropped in price since then with the launch of the extreme edition processors. With Skylake's release (and dual-channel support) comes a wide variety of dual-channel kits at almost a comparable price point to DDR3. If you're still unsure what memory to choose, however, don't worry. Intel has you covered. Memory kits from the likes of Crucial, Corsair, G. Skill, Patriot, Kingston and Adata have all been approved by Intel, just to keep you safe of mind.

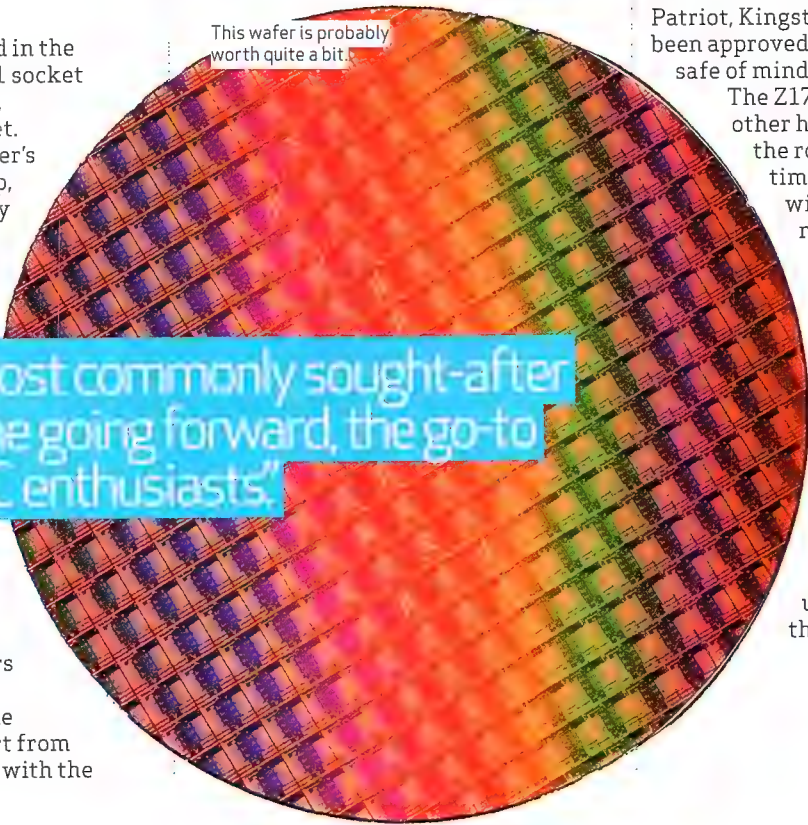
The Z170 motherboards, on the other hand, have been making the rounds for quite some time now, debuting with a wide variety of manufacturers showing off their long-awaited products at Computex, back in June. And man, do they look good! Most mainstream board partners have had these things ready since last Christmas (or thereabouts), so if you must have the latest hardware, or are thinking it's time for an upgrade, you'll be more than spoilt for choice.

This wafer is probably worth quite a bit.

"It'll be the most commonly sought-after processor line going forward, the go-to buy for us PC enthusiasts."

enthusiasts, overclockers and system builders looking for the best mid-range processors for our towers of power.

To build a processor like Skylake, you have to start from the ground up, and that's with the



DirectX 12 could well be a game changer, literally.

A screenshot from a video game showing a character riding a horse through a lush, forested landscape at sunset or sunrise. The scene is rendered with high detail and vibrant colors, showcasing the capabilities of DirectX 12. The character is seen from behind, riding a dark horse. The background features a dense forest with trees in various shades of green and brown, and a bright, hazy sky with a large sun or moon low on the horizon. The overall atmosphere is serene and beautiful.

So, how does Skylake actually perform? Well, it isn't the absolute be-all-and-end-all of chip advancements. If you're only one generation behind, with Devil's Canyon, you'll only see around a 10-15% improvement in benchmarks and rendering times, clock for clock.

What is interesting is how far we can push the powerful four core. Skylake's overclocking potential is well documented as being far greater than that of its last three predecessors. And once we cranked our chip all the way up to 4.8GHz (a conservative clock, admittedly), we actually managed to push this core to perform just a little under that of an i7-5820K extreme edition processor at stock. Interested? You should be. It's certainly not impossible to get this processor even higher than that. Reports have come in of people clocking 5.2GHz on air alone, all dependent on the motherboard more so than ever. In fact, we managed to achieve these benchmarks on an entry-level ASUS motherboard.

the chase. Why is 11% good? Is it really worth it? Well, consider it this way. If it's 10% better than an i7-4790K, it'll be roughly 20% better than a 4770K, and 30% better than a 3770K, and so on.

EFFICIENCY DRIVE

95 & FurMark), the rig pulled a total of 340W from the wall, utilising only half of the 750W power supply we had it running on. If nothing else, these chips will be fantastic for small form-factor builds and Steam Machines. Hell, if you really wanted to, you could run SLI on a 750W power supply with little-to-no worries at all.

[illegible]

Overclocking Potential

Inherently, this generation of chips is vastly different to Haswell and the Devil's Canyon remit that we received last year. Primarily, this is down to Intel's decision to remove the FIVR from the chip design.

The FIVR, or Fully Integrated Voltage Regulator, was a component piece of the CPU found in any previous generation of Intel processor. Its sole purpose was to regulate and control the overall voltage that went directly into each part of the compute portion of the CPU, such as the DRAM controller, and the VCore. By removing this, Intel has handed voltage control

to the motherboard manufacturers. This means that, instead of a standardised level of voltage operating across the entire platform, it's now possible for board partners to implement specific voltages for each of those compute portions we mentioned earlier.

But are they cooler than Devil's Canyon? Skylake is quite cold, no doubt partly due to the removal of the FIVR we mentioned earlier. This enables you to ramp up the core clock frequency considerably, without worrying about thermally throttling the chip. But you're still going to need an aftermarket cooler for the majority of your overclocking attempts, as it will provide a great deal more headroom when trying to achieve those higher clockspeeds.

BASE CLOCK BATTLES

In our testing, we found the Core i7-6700K to be a solid 3-4°C cooler than the Devil's Canyon refresh under load. And although Intel has promised to

reimplement the FIVR, this doesn't seem likely to happen until the iteration after Kaby Lake, known as Ice Lake. All in all though, we're not too sure whether losing the FIVR is a bad thing or not.

Another change that's come with Skylake is the ability to alter the base clock frequency in 1MHz increments. The base clock frequencies are currently 100/125/166MHz on Devil's Canyon. However, Skylake scraps the ratio-based system entirely, allowing higher overall overclocks for those willing to eke out every millimetre of power from their otherwise beastly new CPU.

It's important to note, however, that you'll need to adjust the core ratio to coincide with what target clockspeed you're attempting to achieve. For example, if you change the base clock to 300MHz and leave the core ratio at default, you'll end up trying to achieve a 12GHz overclock. Which, we think, is theoretically impossible at this point in time.

The Core i7 still rules the roost when it comes to overclocking potential.

Supported on Intel® Core™ i7-6700K and i5-6600K Processors with Intel® Z170 Chipset Only

Feature	i7-4790K	i7-6700K	Details
Fully Unlocked Turbo	Yes	Yes	Software/BIOS controlled ratio
Base Clock (BCLK)	Ratio-based 100/125/166	Full	Full Range, 1 MHz increments
DDR Ratio Override Capabilities	DDR3 Up to 2667 MT/s	DDR4 Up to 4133 MT/s	Ability to increase memory frequency
DDR Granularity Steps	100/266 MHz	100/133 MHz	Finer grain increments



DX12 and Skylake gaming-capable laptops anyone?

Conclusion

So, what does Skylake mean to PC enthusiasts? Well, probably that it's finally time for an upgrade, for starters. Intel is still top dog when it comes to single and multi-threaded processor performance, and this looks unlikely to change any time soon.

Hopefully, AMD will bring back some competition via the upcoming Zen cores, but who knows how far off that will be. What these K-series processors have shown us, however, is that Intel's famously weak integrated graphical horsepower has been increased considerably compared to the last series. And, although those running the overclockable chips are hardly likely to be utilising integrated graphics alone, this does give us a good insight into the capability of the more mainstream chips being released later this year, which is



Intel has rebranded the packaging, just to entice you that little bit more.

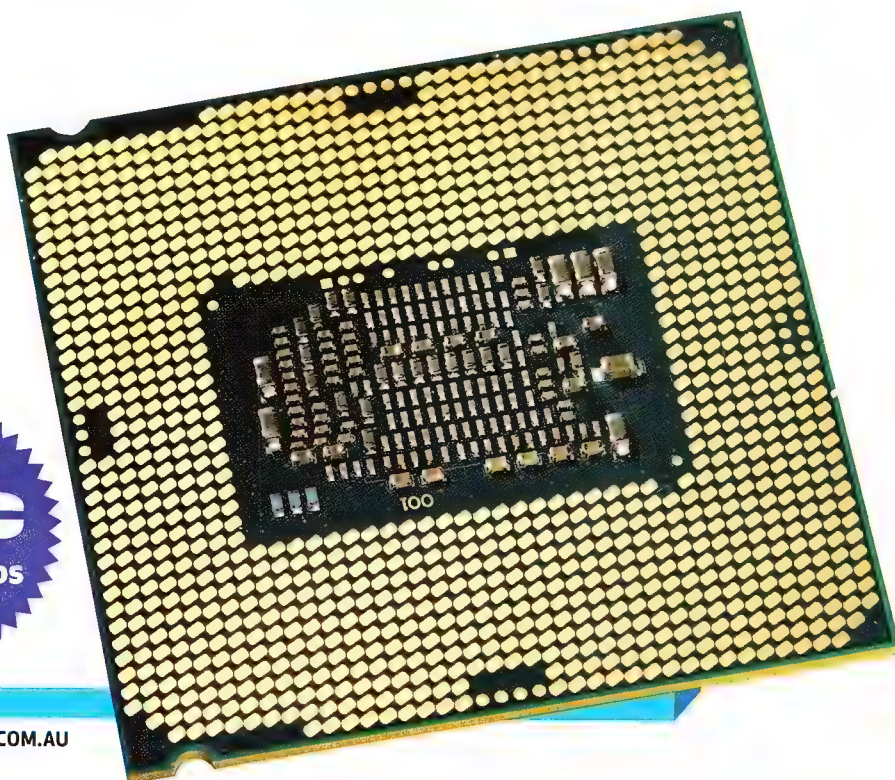
especially interesting for those running laptops and other Intel-powered mobile devices.

PROMISING FUTURE

As much as Skylake is still an incredibly competitive chip, however, it still doesn't hold pace with Haswell-E. The extreme edition processors benefit hugely from

the additional cores, and no amount of Hyperthreading or core performance will beat that for the time being. What we did find during our testing of Skylake was that if you overclocked the CPU up to 5GHz, it actually matched benchmark performance with that of the entry-level model i7-5820K at stock. For an enthusiast-grade chip, that's one hell of an achievement.

Over the next few years, we'll no doubt see some incredible advancements when it comes to computational power. If Intel keeps this progress up, 10nm processors might not be as far away as many may think. And with 3D Xpoint landing sometime next year, the next phase may change how we look at the world entirely. It's an exciting time to be a tech enthusiast, that's for sure. ■



CPU

\$549 | WWW.INTEL.COM.AU

Intel Core i7-6700K

Another quad-core? Yup, but this one's different...

First the bad bit. The all-new Intel Core i7-6700K does not tear PC gaming a new one. It's not a render monster like none before. It doesn't take desktop number-crunching to a whole new level. Bummer.

Instead, it's yet another bleedin' Intel processor with four cores, eight threads and a habit of humming along at about 4GHz. Isn't that what Intel's top processors for its mainstream platforms have looked like forever? In fact, it's the way things have been since the arrival of Sandy Bridge, all the way back in late 2010.

Of course, we've been complaining about the glacial rate of progress at Intel for so long now that you might expect this latest mediocrity to have us pondering the possibility of putting an end to it all by stringing ourselves up with SATA cables. After all, you could say the aforementioned glacial progress thing is actually a

bit kind. If anything, Intel has actually backtracked in recent years, courtesy of silliness such as dumbed-down chip packaging and cooling, along with increasingly locked-down overclocking.

CORE OF THE ISSUE

So it's true, we're not exactly blown away by this new chip itself. And yet, it's still the most exciting, mainstream Intel CPU for years. How so? Let's start with the basics, even if they are a bit boring.

The Core i7-6700K is one of two launch chips representing the new Skylake family of 14nm CPUs. The other is the Core i5-6600K. This i7 and its quartet of unlocked Hyperthreaded cores rocks in at 4GHz nominally, with a 4.2GHz Turbo clock. Yup, just 200MHz-worth of Turbo boost. Why even bother?

Anyway, it slots into the new LGA1151 socket and thereby hooks into Intel's new 100-series chipsets, the most notable of which, for we performance junkies, is

the Z170, which effectively replaces the old Z97. Graphics-wise, there's an Intel HD Graphics 530 core onboard, and thus not one of the fancy new Iris or Iris Pro solutions. Got dat?

Whatever, Skylake is a 'tock' in Intel's tick-tock chip development parlance, and that means it's supposedly an all-new processor design on an existing production node, in this case 14nm. Except, we've barely seen any of the first 14nm chips, known as Broadwell, on the desktop. And now Skylake is go for launch. Put simply, Intel's CPU roadmap has gone completely out of whack.

The other problem, when it comes to improving CPU performance, is that Intel's CPU engineers snaffled up all the low-hanging fruit long ago. Then they climbed the branches and grabbed everything else. And now there's almost nothing left. Intel's CPU cores are outrageously optimised.

That explains why our benchmark results show

such a modest uptick in raw CPU performance. It's all of 4% faster than the existing Core i7-4970K in Cinebench. Bleh. As for video encoding, you're looking at a 6% leap. Hardly exciting stuff.

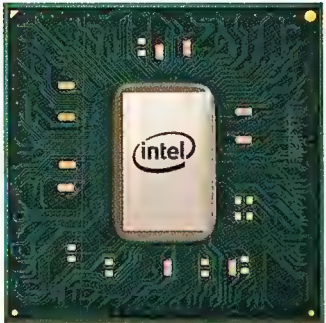
INCHING FORWARD

The game benchmarks are arguably even less dramatic. At the kinds of resolutions that a fairly pricey chip like this is likely to find itself operating, the impact of the 6700K is slim going on none. If you've got a fast Intel Haswell process or an Ivy Bridge chip, hell, maybe even a Sandy Bridge chip, you probably won't feel much subjective difference with Skylake. It's just not a big enough step forward. And if you're wondering why the weirdo chip that is the Broadwell Core i7-5775C has the edge in some of the game benchmarks, that's probably thanks to the 128MB of eDRAM, something the new Skylake Ks lack.

The two obvious solutions to this problem, of course, are clockspeed and cores.

LABS BENCHMARK RESULTS

Performance Category



"The problem is that Intel gave up on chasing clockspeeds a decade ago and it's simply not under enough pressure from AMD."

Faster clocks or more cores would give added punch, even if the cores themselves remained essentially the same. The problem is that Intel gave up on chasing clockspeeds a decade ago and it's simply not under enough pressure from AMD to force it to add more cores to its mainstream chips.

Indeed, some would argue more cores wouldn't help much in most apps, including games. But we're not so sure. Build it and they will come has been an effective policy for the PC in years gone by. If six cores for gamers became the norm, game developers would make use of them.

But never mind that. So far, we've painted a picture of an unexciting CPU that's part of a fairly broken CPU launch schedule from Intel. Where the hell does the excitement come in?

Platform details and overclocking are the answers.

HIGH HOPES

For starters, Intel has doubled the performance of the DMI interface that links the chipset to the CPU. That means you can hook up a really fast M.2 SSD with four PCIe lanes to the chipset and get the maximum possible performance out of it. Yay.

But the best bit involves overclocking. There are a few changes that are significant, and for the most part they are really good news. For starters, there's no more baseclock strap, so you have full access to baseclock overclocking. In other words, on paper you can overclock these things via the bus like the good old days of the LGA775 socket and earlier.

Then there's the voltage regulator that's been taken off the CPU and put back on the motherboard, giving finer control of voltages for different sections of the chip. Finally, don't forget those 14nm transistors. They should be hot for some overclock trot, no?

In the case of this Core i7-6700K, the full overclocking potential isn't that spectacular. We've got two Core i7-6700Ks in for testing. One hit 4.8GHz, the other 4.6GHz, albeit the latter was on a different motherboard, which could skew the results, especially as the motherboard is now responsible for voltage regulation.

What's really exciting is that we achieved the same overclocking results using the baseclock as the CPU multiplier. So here's the bombshell. This could mean

that the days of buying a cheaper chip and clocking the twangers off it could be about to return. For now, the jury is out. And the 6700K itself isn't hugely exciting. But what it hints at for possible cheaper Intel processors in the near future is utterly tantalising. Fingers crossed.

■ Jeremy Laird

Verdict

Features	★★★★★
Performance	★★★★★
Value	★★★★★

Excellent power efficiency, impressive low temps and a great CPU graphics core, but it's slightly pricey at launch.



Z170 on test

Lindsay Handmer takes 10 new motherboards based on Intel's new Z170 chipset for a spin.

Skylake is here – pairing up with the Intel Z170 chipset using the LGA 1151 socket. With better overclocking, faster DDR4 support, new drive options and more PCIe bandwidth, these motherboards offer serious performance. They also all support 10GB/s USB 3.1, and have both a new USB Type-C and standard Type-A port. All the boards also have at least one M.2 SSD slot, as well as SATA Express.

The tested motherboards offer quite close performance across the same class and from the best to the worst the difference is typically only a few percent. The moral here is to carefully examine what extra features

you need, as this is often the major difference between brands. Integrated audio is only getting better (especially on high end boards) and it's starting to become hard to tell the difference between sound quality unless you have audiophile quality gear. Don't discount the free included software suites either – the utilities can be very useful.

At the time of writing CPUs are only just becoming easier to get and most

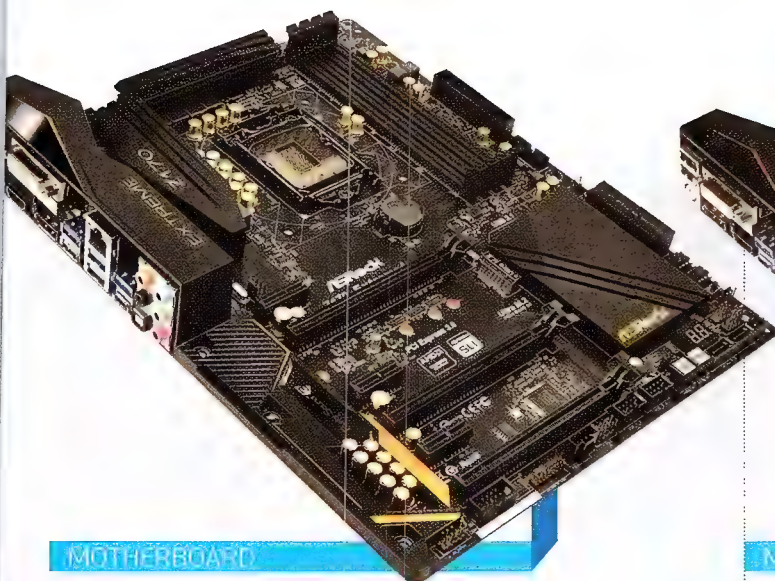
motherboards are still selling over their RRP's. If you want to save a little money, hold off upgrading just yet as prices settle down.

We tested with an Intel Core i7 6700K, 8GB of G.Skill Ripjaws V Series 3000MHz DDR4, an Intel 750 SSD, an ASUS GTX 980 Ti GPU and a Thermaltake FrioSilent 14 Heatsink. Benchmarks were run at 1080P on high and overclock testing was performed with stock voltages running at 4.5GHz.

“From the best to the worst, the difference is typically only a few percent.”

BENCHMARKS

		ASUS ROG MAXIMUS VIII HERO	ASUS Z170-AR	GIGABYTE Z170X-GAMING G1	MSI Z170A GAMING M9	ASROCK Z170 EXTREME 7+	ASROCK Z170 EXTREME4	GIGABYTE GA-Z170X-SLI	MSI Z170A GAMING M5
INTEL TUNING	4GHZ	1198	1188	1193	1196	1190	1178	1187	1178
UTILITY	4.5GHZ	1261	1249	1229	1257	1221	1201	1219	1208
PCMARK 8 HOME		4944	4888	4903	4938	4912	4802	4835	4875
3DMARK FIRESTRIKE		16194	16123	16021	16204	16125	16006	16005	16142
GRID 2 AVERAGE FPS		204.04	197.52	198.95	204.78	197.85	195.58	196.24	198.65
COH 2 LOW	MIN			70.44				69.00	
	MAX			135.19				132.47	
	AVERAGE			95.36				93.25	
COH 2 HIGH	MIN	39.60	39.12	40.76	39.88	39.71	41.25	38.78	39.12
	MAX	111	110.81	119.64	111.77	115.69	105.87	112.45	112.78
	AVERAGE	73.96	72.54	74.67	73.69	75.47	69.88	72.45	73.14
CINEBENCH R15 CPU MULTI		916	904	913	925	912	890	894	911
CINEBENCH R15 CPU SINGLE		181	180	180	182	180	180	181	181
CINEBENCH R15 OPENGL		161.38	151.29	155.05	152.14	154.78	149.83	149.98	151.68
CINEBENCH	MULTI	979	969	968	973	967	965	966	970
4GHZ CPU	SINGLE	194	190	191	192	190	190	192	191
X264 5.01	P1	78.75	75.97	77.09	77.62	77.14	73.62	74.35	75.89
	P2	20.66	20.25	20.35	20.55	20.47	19.14	19.54	20.17
PASSMARK MEMORY SCORE		2848	2825	2818	2852	2847	2809	2801	2813
AS SSD SEQ	READ MB/S	2136.61	2087.27	2119.06	2123.19	2117.55	2014.9	2029.5	2045.56
READ	WRITE MB/S	1210.42	1198.26	1222.70	1221.94	1220.47	1188.8	1157.2	1201.36
AS SSD 4K	READ MB/S	35.65	32.89	35.31	33.21	33.23	31.5	32.3	33.19
	WRITE MB/S	209.30	194.54	198.56	204.65	184.70	183.25	193.49	192.58
AS SSD SCORE		3857	3819	3816	3837	3814	3802	3809	3821
CRYSTADISK-	READ MB/S	1226	1999	1262	1209	1189	1169	1173	1198
MARK SEQ	WRITE MB/S	1273	1278	1295	1283	1269	1278	1277	1271
CRYSTADISK-	READ MB/S	38.31	36.14	36.98	33.94	36.65	36.23	35.49	34.28
MARK 4K	WRITE MB/S	275.3	236.13	239.9	218.3	234.1	231.5	247.2	235.1
AUDIO QUALITY (OUT OF 5)		4.5	3.5	4	4	4	3.5	3.5	3.5



MOTHERBOARD

\$249 | WWW.ASROCK.COM

ASRock Z170 Extreme4

Is it worth saving a few extra dollars?

Rather than totally scrimping, the Extreme4 is about providing essential features, without going totally overboard or being flashy just for the sake of it. It's rated for up to 64GB of 3200 MHz (OC) RAM and has three 16x PCIe slots (and another three 1x) that support CrossFire and SLI. The Asrock board also has a M.2 slot, 3x SATA Express and 6x SATA III. All in all, pretty well equipped. The board is well laid out and has plenty of space to easily install RAM or a CPU cooler without losing a finger. For those who want to have a little fun with their new CPU toys, the Extreme4 has onboard power buttons and is a capable overclocker. The BIOS is comprehensive, though not quite as polished as some of its more expensive brethren.

The Extreme4 isn't taking out any awards for the highest benchmark results,

but if you crunch the numbers it's so close as to not make any real world difference. The Asrock motherboard also does particularly well with a small overclock and nets a solid boost. Audio quality is quite good (but not on the same level as the more expensive boards), and is driven by the Asrock Purity Sound 3 system which uses the Realtek ALC1150 codec.

The Extreme4 has a solid connectivity line-up -- with HDMI, DisplayPort and DVI connections. You also get a USB Type-C port, plus six USB 3 ports and Gigabit LAN connection. The Asrock has the usual array of 5 3.5mm audio jacks, plus SPDIF optical.

Verdict

Plenty of potential and features for those determined to stick to a budget.



MOTHERBOARD

\$389 | WWW.ASROCK.COM

ASRock Z170 Extreme7+

A surprisingly subtle top-shelf motherboard.

The black and gold of the Extreme7+ is quite understated, but don't mistake this board for anything but high end. It can handle 64GB of 3600MHz (OC) RAM and has four PCIe x16 slots that can handle quad SLI and Crossfire. The board also has not one, not two, but three Ultra M.2 4x SSD slots.

So how does it perform? Not surprisingly, really well. In particular, the Extreme7+ squeaked in with the highest average frame rate in *Company of Heroes 2*. It also pushed the RAM hard, though was a touch slower for drive access. The Asrock integrated soundcard implementation is excellent, and probably better than your headphones or speakers unless you have some seriously good audio gear on your desk.

Overclockers and tinkerers will like the onboard power and reset buttons and comprehensive BIOS. Compared some other

(more expensive) high end boards, the Extreme7+ doesn't include any Wi-Fi. You do get a half size mini PCIe card slot though, which makes it easy (though not cheap) to add the extra functionality. As a consolation, the board has a slightly ugly USB 3.1 front panel, with both Type A and Type-C ports and a fairly good package of free software. On the plus side, the Extreme7+ dual Gigabit Intel LAN ports. It also has a USB Type-C port, plus one USB 3.1, four USB 3.0, two USB 2.0 and a PS2 connection. For video, it features HDMI, DisplayPort and DVI, while audio is handled by 5x 3.5mm jacks plus SPDIF optical.

Verdict

Great performance if you need the specific set of high end features but also want to skip the bling.





ASUS ROG Maximus VIII Hero

With standout controllable LED board lighting.

The ASUS board is the second most expensive board of those tested but only just ahead of its rivals – so what does the extra money buy? The Hero is totally focused on gamers, so is built to maximise performance, whilst also providing features such as high end integrated audio. The board can handle up to super fast 3733MHz DDR4 (OC), as well as SLI or CrossFire over three PCIe x16 slots. Designed for those who want to try some fairly hard-core overclocking, the Hero has on-board power buttons and a host of OC friendly features.

As expected, performance is extremely good, and the Maximus VIII Hero easily tops out many of our benchmarks. Gaming frame rates are top notch, and it's easy to squeeze out a performance boost through overclocking. In particular, memory and drive performance was a cut

above the competition. Audio is provided by SupremeFX, which is possibly the best integrated soundcard we have ever laid ears on.

The Hero comes with a funky little plastic tool for the paranoid types that makes it easy to install a CPU with no risk of bending contacts. It also includes the excellent ASUS suite of software for setting up and tuning your PC. Round the back it's got USB 3.1 (Type C and A), USB 3.0, HDMI, DisplayPort, Intel Gigabit LAN plus a PS2 port.

While the Hero is a very powerful motherboard, it is focused on gaming and overclocking, and misses out on extras such as a front USB 3.1 panel.

Verdict

Absolutely top notch performance, but a very focused set of features that may not appeal to all.



ASUS Z170-AR

Affordable without ditching the features you need.

A bang for buck mid-range motherboard, the ASUS Z170-AR still works hard to stand out. Notably, it can handle up to 3400MHz overclocked DDR4 and can run Crossfire or SLI over three PCIe x16 slots. It also sports the typical M.2 SSD slot, as well as SATA Express and six SATA III connections. The AR board also has a water pump header that adds in an extra layer of control, essentially giving your cooling system a free upgrade.

Considering the price difference, the Z170-AR keeps up with its more expensive ROG brother quite well for strong all round performance. In fact, it's hard to pick the board's biggest strength, though gaming is up there. The ASUS BIOS is also worth a special mention, as it's one of the best we have used at this level. The ASUS Crystal Sound 3 is solid (though a step down from the ROG

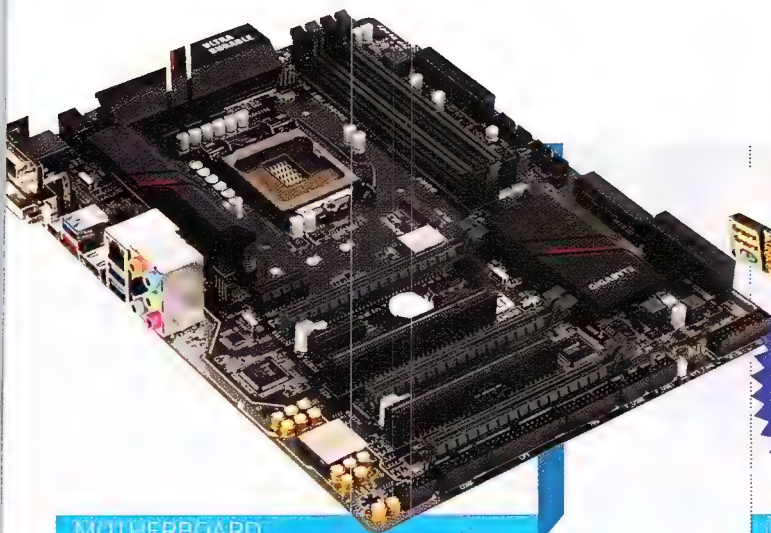
offering), has built in de-pop and can interface with your surround sound system via 3.5mm audio jacks or SPDIF output. Round the back the ASUS has the standard Z170 USB 3.1 Type-C port, as well as one Type-A. You also get another two USB 2.0 and two USB 3.0 ports, plus an array of extra connectivity through internal headers. The Z170-AR has Gigabit LAN as well as DisplayPort and HDMI outputs.

The ASUS board also comes with an array of excellent software, which makes it easy to optimise everything from cooling to bandwidth use, or try your hand at overclocking.

Verdict

An affordable board that's more than the sum of its parts.





MOTHERBOARD

\$259 | WWW.GIGABYTE.COM.AU

Gigabyte GA-Z170X-SLI

This is what mid-range gaming looks like.

Understated yet still sporting all the features you crave, the Gigabyte mid-range offering packs an affordable performance punch. The Z170X-SLI will accept 4 RAM chips up to 64GB and can run it at 3466MHz, overclocked. The board has a single M.2 slot, plus three SATA Express and six SATA III ports for whatever combination of SSDs needed. It also features three PCIe x16 slots that can handle 3 way CrossFire or 2 way SLI.

Installing a CPU cooler and RAM is straightforward (though a tiny bit tight on one side) and there is plenty for space for big GPUs without overcrowding. The BIOS is excellent, and Q-Flash made it very easy to update to the latest version from a USB drive.

Considering the GA-Z170X-SLI is one of the more affordable boards out there, it does our suite of benchmarks quite a lot of

justice. The Gigabyte audio implementation uses the Realtek ALC1150 – and it's pretty good. You can even set the LED lighting to beat along with your music.

Round the back you get old school VGA, DVI and HDMI and can actually run three monitors at once. The Z170X-SLI has six 3.5mm audio I/O plugs, Intel Gigabit LAN and dual USB 2 ports. You also get a USB Type-C, plus another USB 3.1 connection backed up by three USB 3 ports.

The Gigabyte board comes with a solid array of software, including an app center where you can install utilities for overclocking or setting up your own cloud.

Verdict

Exactly what you want and expect from an affordable Z170 motherboard.



apc
RECOMMENDS

MOTHERBOARD

\$799 | WWW.GIGABYTE.COM.AU

Gigabyte GA-Z170-Gaming G1

Aimed at enthusiasts who want and can afford it all.

The svelte G1 features four metal reinforced PCIe x16 slots and can run quad SLI or Crossfire. You can also slot in up to 64GB of RAM and overclock it up to 3666MHz. Drive connectivity is excellent, with two M.2 connectors, three SATA Express connections and six SATA III ports.

The G1 chipset has built in water cooling connectors, but also sits nice and low for those who want to use a large heatsink. The first PCIe slot does sit very close to the CPU though, but is unlikely to be an issue as most users would opt for water cooling over air.

The G1 has onboard power and OC buttons, as well as voltage measurement points for overclockers. The BIOS is excellent and updates via Q-Flash are painless. The Gigabyte board uses Creative audio, with 5x 3.5mm jacks and SPDIF optical output. Not surprisingly the sound

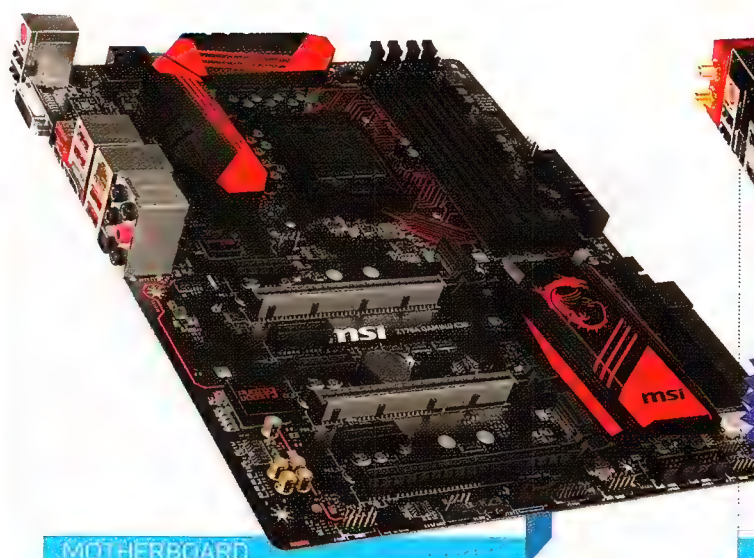
quality is excellent and it scores highly in the audio benchmark. While the Gigabyte board gives strong gaming grunt, it also manages to really push the CPU. A mild overclock sees a healthy performance bump with no need to tweak the voltages.

The G1 has Killer powered dual band 802.11 AC Wi-Fi and (dual) Gigabit LAN ports, as well as Bluetooth. There is a single HDMI connection round the back, as well as USB 3.1 delivered through Type-C and A ports. You also get a front mount USB 3.1 panel and seven 3.0 USB ports as well as legacy PS2.

Verdict

A very feature packed board with an eye watering price.





MOTHERBOARD

#329 | AU.MSI.COM

MSI Z170A Gaming M5

Striking in black and red.

The Z170 based board has the usual array of goodies – dual memory channels with 4 slots for up to 64GB of RAM at 3600MHz (OC) and three PCIe 16x slots (plus four x1) that can handle SLI or CrossFire. Drive connectivity is great, with two M.2 slots (supporting RAID), dual SATA express and six SATA III connections.

The CPU area is clear, making installing a large cooler simple, though a big heatsink can overhang one M.2 slot and the RAM a little. The UEFI BIOS is well laid out and easy to navigate, while still offering powerful customisation. The MSI board can handle itself when it comes to overclocking, with a post display and slow down switch, though no on board power buttons.

The M5 has a RRP of \$265, but at the time of writing it was not possible to find for even close to that price. While overall performance was outstanding, it is worth

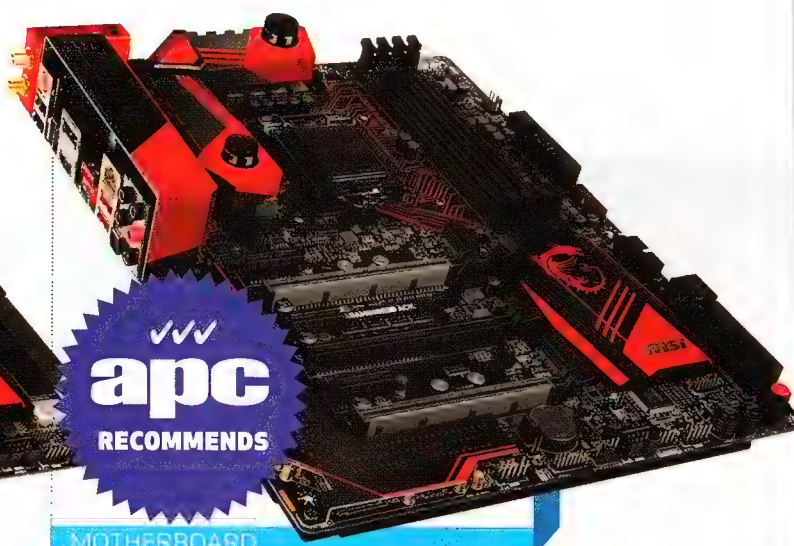
tempering that slightly when comparing to mid-range boards that are a lot cheaper. Still, in 3DMark and some gaming benchmarks, the M5 bested even more expensive motherboards.

Of course, the M5 also features a USB Type C port, as well as a 4 USB 3.1 connections as well as front headers for two more. You also get a (legacy) PS2 port, DVI, HDMI and Gigabit Killer LAN. Audio connectivity is good, with 5x 3.5mm I/O plugs (though annoyingly 4 are black) and an Optical SPDIF.

The MSI board also has a fairly comprehensive software package, such as RAMdisk and streaming utilities.

Verdict

On the upper edge of mid-range, the M5 nevertheless offers a lot for the admittedly high price.



MOTHERBOARD

#639 | AU.MSI.COM

MSI Z170A Gaming M9

Solid as a rock.

On first impressions, the M9 actually feels heavy in the hand. It's partly from the aluminium clad back, partly from the re-enforced PCIe slots and partly from the water cooling ready chipset heatsink. The result is a seriously high quality feeling board.

The M9 supports 3600MHz (OC) DDR4 and has three PCIe 16x slots that handle both CrossFire and SLI. It's worth noting that the large chipset heatsink could impact wide air coolers (water cooling is where it is at) and the rear armour could interfere with some backing plates. The M9 has dual M.2 SSD slots, as well as SATA Express and six SATA III connections.

The M9 is neck and neck for the best performing motherboard tested, and tops out quite a few of the benchmarks. In particular, it excels at getting the most from gaming. It also pushed the CPU hard and can

extract quite a bit of extra grunt from even a small overclock. Hardcore overclockers will enjoy the on-board buttons, post display and voltage measurement points. For the rest of us, the MSI will do a pretty decent job of overclocking for you. If you do mess something up, the BIOS can be recovered with no CPU or RAM installed.

Round the back you get dual 802.11ac Wi-Fi, as well as a USB Type-C connection and a normal style USB 3.1 (gen2) port. There is also two stand USB 3 connections, plus three USB 2 and even PS2. Rather than the usual single HDMI output, you also get DisplayPort, plus 5x 3.5mm audio jacks and SPDIF optical. ■

Verdict

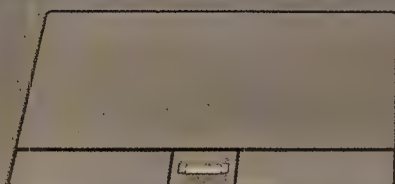
A very powerful and feature packed board that commands a worthy price premium.





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DDR4 on Z170

Lindsay Handmer tests affordable DDR4 kits perfect for accompanying a new Z170 'board.

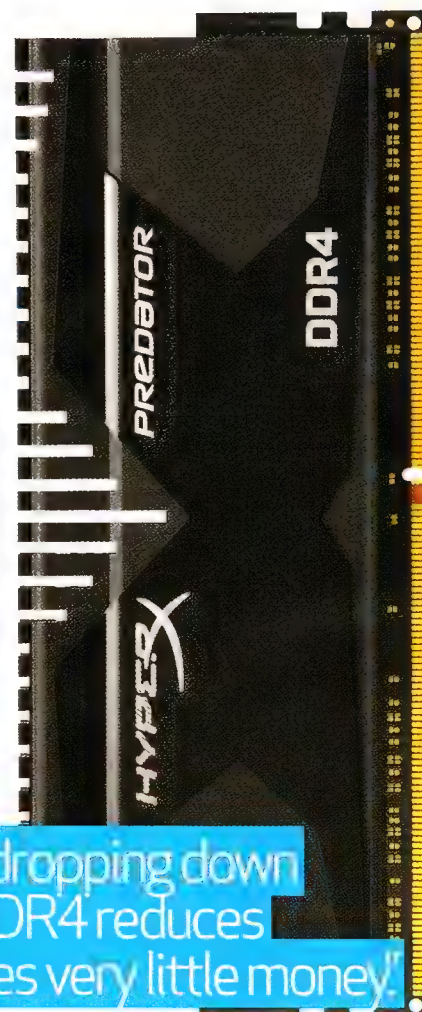
DDDR4 has been around for quite a while now, finding a home in countless X99 motherboards. But with new Z170 options, the need for powerful yet affordable DDR4 is much greater. Fortunately, prices have been steadily dropping and it's possible to get 8GB of reasonably-fast DDR4 for as little as \$100.

The latest RAM on the market is optimised for use in Z170 motherboards, but that doesn't mean older DDR4 won't work. The newer kits tend to be cheaper, but if you already own DDR4 then it should be good to go. For some motherboard/RAM combinations you might need to enter the RAM timings manually. Otherwise, make sure you enable the XMP profile and update to the latest BIOS for the best compatibility.

Thanks to the better memory controller on Intel's Skylake CPUs, you can also expect to be able to run DDR4 at much higher frequencies than on older X99 systems.

When comparing RAM, both the frequency and CAS latency needs to be taken into account. The performance increase from a bump in MHz can be negated by a higher latency, as well as give different advantages for varying memory use.

For uses such as gaming, the sweet spot is between 2,666MHz and 3,000MHz, with latencies as low as possible. Anything faster and the tiny bit of extra performance is arguably not worth the extra cost – unless you have a specific use for all that memory bandwidth. With current prices, dropping down to lower-frequency DDR4 reduces performance but actually saves very little money.



"With current prices, dropping down to lower frequency DDR4 reduces performance but saves very little money."

BENCHMARK RESULTS

	CORSAIR VENGEANCE LPX	CRUCIAL BALLISTIX ELITE	KINGSTON HYPERX FURY	ADATA XPG DDR4	APACER COMMANDO	GEIL SUPER LUCE	G.SKILL RIPJAWS V	SILICON POWER DDR4	KINGSTON HYPERX PREDATOR
FREQUENCY MHZ	2,666	2,666	2,666	3,000	2,800	3,000	3,000	2,133	3,000
TIMINGS	16-18-18-35	16-17-17-36	15-17-17-35	16-16-16-36	17-17-17-36	16-16-16-36	15-15-15-35	15-15-15-36	15-16-16-39
SIZE GB	2X 4GB	2X 8GB	2X 8GB	2X 8GB	2X 4GB	2X 4GB	2X 4GB	2X 4GB	4X 4GB
PRICE	\$110	\$235	\$210	\$240	\$169	\$120	\$135	\$85	\$350
DOLLAR PER GB	14	15	13	15	21	15	17	11	22
AIDA64 READ MB/S	43,678	43,736	43,721	43,546	39,746	42,846	43,002	38,987	43,166
AIDA64 WRITE MB/S	45,226	45,386	45,371	45,374	41,649	45,021	43,999	41,274	44,909
AIDA64 LATENCY NS	45.2	45.4	47	46.9	48.3	45.1	44.2	48.7	44.4
PASSMARK SCORE	3,604	3,608	3,610	3,594	3,162	3,292	3,319	3,099	3,298
PASSMARK DATABASE OPERATIONS	123.7	123.9	127.8	125.2	119.2	125	125.9	118.1	123.6
PASSMARK READ CACHED MB/S	31,869	31,863	31,873	31,863	31,873	31,853	31,873	31,852	31,853
PASSMARK READ UNCACHED MB/S	20,877	20,908	20,929	20,707	19,954	20,782	20,907	19,947	20,837
PASSMARK WRITE MB/S	17,450	17,453	17,252	17,470	15,620	16,937	17,111	15,473	17,078
PASSMARK LATENCY (LOWER IS BETTER)	18.9	18.6	19	18.9	19.7	18.4	18	19.8	18.2
PASSMARK THREADED MB/S	38,425	38,321	38,525	38,160	34,834	37,471	37,744	34,734	37,629
SISOFT SANDRA MEMORY GB/S	36.49	36.52	36.63	35.89	29.13	31.42	31.86	29.11	32.08
NOVABENCH TRANSFER SPEED MB/S	24,199	24,223	24,086	24,073	21,248	22,584	22,915	21,056	22,968
3DMARK FIRESTRIKE	15,729	15,740	15,653	15,754	15,761	15,716	15,674	15,623	15,739
GRID 2 AVERAGE FPS	232.11	235.12	234.94	229.72	216.17	228.87	229.61	220.72	231.32
CINEBENCH R15 CPU MULTI	928	932	935	933	928	924	929	928	937



\$240 | WWW.ADATA.COM

ADATA XPG DDR4

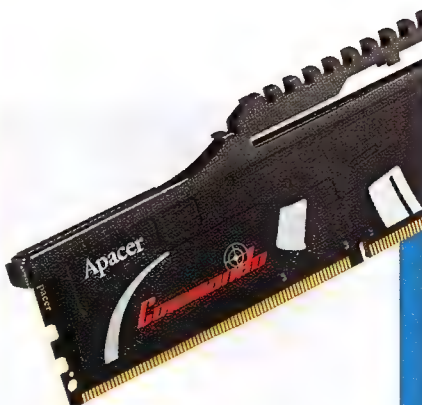
Breaking from the usual tradition of black, black and more black, the ADATA XPG DDR4 modules stand out. Aimed at gamers, the dual channel RAM is rated from 2133MHz all the way up to 3333MHz. Each speed has a range of timings available, and comes in 8GB or 16GB kits. The slower DDR4 is sheathed in red, rather than gold, but still adds a little bling to a new Z170 system. In our test bench is the dual channel 16GB 3000 MHz DDR4, with timings of 16-16-16-36 at 1.35v. Performance is excellent across our benchmark suite and is a solid choice for gamers.

For larger capacities, you need to upgrade to a quad channel kit, available with the same timings and frequencies, but up to a 32GB capacity. Going all out is hard on the wallet though, and a 2800MHz (the fastest currently available) 32GB kit costs around \$700.

If you want a more budget friendly DDR4 option, ADATA also has an upcoming Premier DDR4 lineup.

Verdict

A safe bet with middle of the road performance and price.



\$169 | AP.APACER.COM

Apacer Commando

Unlike the normal (and sometimes boring) DDR4 heat spreaders, the Apacer Commando lives up to its name with an assault rifle shaped "tactical" outline and highlights. No doubt it doesn't cool any better than the other options, but it stands out.

More important perhaps is that the Commando on hand runs at 2800MHz, though is also available in 2400, 2666, 3000, 3200MHz modules. You can also get it in 8GB (as tested) or 16GB dual channel kits, though at the time of writing it was not yet available for sale.

The Commando has OK but not top notch 17-17-17-36 timings at 1.35v, and supports Intel XMP 2.0 standards. If you want faster timings or larger capacities, you need to move across to the Apacer Commando quad channel kits instead.

The RRP of \$169 is a little above the competition, so keep an eye out for the retailers offering the best prices. The Apacer Commando will be available for sale in September.

Verdict

A little pricey for the performance, but keep an eye out for price drops.



\$110 | WWW.CORSAIR.COM

Corsair Vengeance LPX

Hidden under a chunky black heat spreader, the Corsair Vengeance LPX DDR4 hums along at 2666MHz with 16-18-18-35 timings at 1.2v. Our test RAM consists of a dual channel 8GB (2x 4GB) kit, though the Vengeance is also available in a huge number of other options. At the tested frequency the Corsair RAM is one of the cheaper options available and still offers compelling performance with a little headroom for overclocking. You can also get the DDR4 in up to 3200MHz, with 16-18-18-36 timings at 1.35v. Even better the price premium is about \$10, though the performance difference is likewise quite small.

For around double the price you can get a dual channel 16GB (2x 8GB) kit instead, with the same frequency and timings. Another option is the quad channel kits (4x 16GB), though these don't offer as good a price per GB. For larger 32GB quad channel Vengeance kits, expect to pay near \$4000 for 2400MHz, or \$600 for 2800MHz.

Verdict

Affordable, yet with enough performance to make it a worthy choice.





\$235 | WWW.CRUCIAL.COM

Crucial Ballistix Elite

Not that we recommend manhandling your RAM too much, but the Ballistix Elite has a chunky, high quality feel. In particular, the heat spreader is thick and screwed rather than pressed onto the RAM. Hidden underneath is 16GB (2x 8GB) of 2666MHz RAM with 16-17-17-36 timings. You can also get the Crucial RAM in 8GB (2x 4GB) options, but the value is not as good. For the same price as the dual channel, you can grab a quad channel 2666MHz 16GB (4x 4GB) kit, or shell out an extra \$220 to upgrade to 32GB (4x 8GB). Unlike some of the competition with endless options, the Crucial DDR4 is only available running at 2666 MHz. On the plus side, there is headroom there to gain some extra speed through overclocking.

All in all, considering the slightly slower frequency, the Elite gave some of the best performance of the RAM tested. Of course it does also command a slight price premium over some of the lesser competition, but it's worth the cost.

Verdict

Strong performance and features for a very slight price premium.



\$120 | WWW.GEIL.COM

Geil Super Luce

Amongst the endless sea of black RAM heat spreaders is the occasional flash of colour, but Geil take it a step further with built in lighting available in white red or blue. Running across the top of the DDR4 is translucent plastic that's backlit by LEDs. A glow or flash would be cool, but Geil took it even further again by coupling the lights up to a temperature sensor that pulses faster the hotter the DDR4 gets.

The RAM itself runs at 3000MHz, with 16-16-16-36 timings at 1.35v. It's a dual channel 8GB (2x 4GB) kit, though it's also available as 16GB (2x 8GB) for around double the price. Those who want quad channel don't have a lot of choice, with only pricey \$300 16GB (4x 4GB) 3000MHz or \$369 3400MHz kits available.

As tested at 8GB, the Geil DDR4 is actually the cheapest 3000MHz kit available in our roundup, despite the fact it offers decent timings and great overall performance.

Verdict

A good buy even if you don't need temperature controlled lighting



\$135 | WWW.GSKILL.COM

G.Skill Ripjaws V Series

The Ripjaws V series attempts to walk the line between affordability and performance, yet also gives peace of mind with a lifetime warranty. We got hands on with the mid-range option, clocking it at 3000MHz. The kit consists of two 4GB dimes, though at this speed it's also available at up to 64GB. The DDR4 has nice tight 15-15-15-35 timings running at 1.35v, and gives excellent performance for the price.

Our test sample is topped by a red aluminium heat spreader, but if you don't like the colour, you can even get it in black, red, silver or grey. The RAM is quite low profile, so won't impact large CPU coolers.

As tested the Ripjaws V series is quite affordable considering the performance. 16GB will set you back an extra \$100 or so, while the 32GB kit is available for \$440. If you want the super high end 3600MHz RAM, be prepared to shell out \$1300. In contrast, the slowest 2133MHz kit is just \$80.

Verdict

Plenty of bang without having to spend too much buck.





\$210 | WWW.KINGSTON.COM

Kingston HyperX Fury

Clad in slimline black, the Kingston HyperX Fury DDR4 series is available in kits from 8GB all the way up to 64GB.

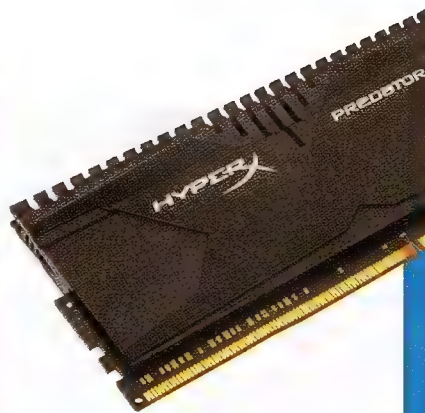
We tested the 16GB kit, which has a fairly affordable price of \$15 a GB. The Fury DDR4 is available in 2133MHz, 2400MHz and 2666MHz speed, with the latter of the three in our test bench. The Kingston RAM sports excellent 15-17-17-35 timing and even better, these are at the minimum 1.2v. The sleek low profile asymmetrical black heat spreaders won't be an issue for CPU cooler installations.

No surprises here – the HyperX Fury performs very well, and manages some of the better scores in amongst the RAM tested. Of course it is slightly more expensive than some of the competition too.

The Fury DDR4 starts at around \$125 for 8GB, and ranges up to \$450 if you want 64GB – though no 64GB is yet available. Dropping back to 2400 and 2133MHz in the 16GB kit will cost \$200 and \$175 respectively.

Verdict

Top notch performance without blowing out the budget.



\$350 | WWW.KINGSTON.COM

Kingston HyperX Predator

Unlike the newer Z170 focused DDR4 offerings, the HyperX Predator was launched for use with X99 boards. But it's no slouch, with a 3000MHz frequency and great 15-16-16-39 timings. You can also get slower 2133MHz Predator RAM, or all the usual steps in between. Capacities range from 16GB up to 64GB.

Performance is quite good (especially for gaming), though the RAM does rate behind the newer Fury DDR4 in some benchmarks. The Predator does have a sizeable heat spreader, though it's not likely to be a problem for the vast majority of cooler motherboard combinations.

You can pick up the slower 2133MHz Predator DDR4 for around \$290, but there isn't much point going for the 2800 or 2666MHz options, as they only save a few dollars at best over the faster RAM.

The Predator has a relatively high cost per GB, but if you can get some for a good price, it's a capable performer. The Predator RAM is also backed by a lifetime warranty like the Fury.

Verdict

Keep an eye out for bargains, otherwise opt for the newer Fury.



\$85 | WWW.SILICON-POWER.COM

Silicon Power DDR4

A high end gaming PC with the fastest possible RAM is great and all, but sometimes it's necessary to build a more down to earth machine, or drop some new RAM in an old motherboard after upgrading. The Silicon Power DDR4 isn't flashy – just plain memory chips on a standard green PCB. Currently in Australia it is available as an 8GB (2x 4GB) or 16GB (2x 8GB) dual channel kit, running at 2133MHz.

In our test bench are the two 4GB modules, which have nice tight 15-15-15-36 timings at 1.2v. While slower than the competition, the Silicon Power DDR4 is also a lot cheaper and offers great bang for buck. It is possible to push the RAM faster, but you need to loosen the timings and not that much is really gained.

On the plus side, the Silicon Power DDR4 is backed by a lifetime warranty. The company also produces quad channel kits, of 16 and 32GB, but these are not for sale locally just yet.

Verdict

Not the fastest DDR4 available, but certainly the cheapest.





State of the ARt

Daniel Griliopoulos explains why augmented reality technology is more than just virtual reality's kid brother.

If you read the tech and video games press, the buzz is all about virtual reality. Valve revealed its long-hidden VR product Vive, built with HTC, in March. Oculus Rift, meanwhile, has been bought for a cool US\$2 billion by Facebook, with Facebook's owner Mark Zuckerberg calling it "the dream of science fiction" that will "unlock new worlds for us all".

Yet quietly, people are whispering that the real story is augmented reality (AR). Influential data firms such as Juniper Research have even put figures on it. Juniper's *Augmented Reality 2015-2019 report* predicts revenues of US\$4.1 billion for AR apps in 2019, with 1.3 billion apps in use. By contrast, Digi-Capital is advising that AR could be worth US\$120 billion by 2020, with VR valued at a mere US\$30

billion. That reflects fundamental differences in both the underlying experience, and the progress made, in each field. We'll explore why that is, and whether virtual reality has any chance of catching up.

As part of that, we'll delve into the way big media corporations – including Microsoft, Valve, Google, Apple and Sony – are looking at this space. Each of them has its own strategy. Several have already invested billions – such as Google with Magic Leap and Microsoft with HoloLens – while others have already walked away, such as Valve, with its deliberate pivot towards VR.

That also means examining how

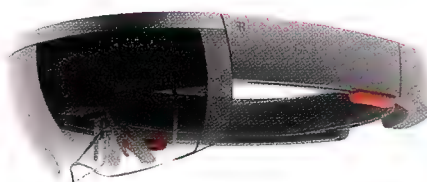
AR tech is currently working, and where the next steps will be. After all, low-grade AR has become commonplace in several types of mobile applications and is looking to become more widespread. Digi-Capital's prediction is based on AR capturing a substantial chunk of the mobile phone market – and with over a billion smartphones already shipped, you could say US\$120 billion was a conservative estimate. But then it's only talking about five years away.

It took 20 years for mobile phones to move from the Nokia Ringo, which could merely call people, to today's all-singing, all-dancing smartphones. For the full lowdown, read on.

"Yet quietly, people are whispering that the real story is augmented reality (AR)."



Valve's Vive has a Batman-style industrial look to it. It needs two base stations to work.



HoloLens is a much smoother design, more 1950s or 1990s chromedome cyberpunk.



The final consumer Oculus Rift hasn't been seen yet, but it's aiming for ski goggle size.

The core difference between VR and AR technology is the worlds they move us into. One replaces, the other improves. Virtual reality creates a new world for you. It may be a world identical to the one you're in now, or it may be a world built entirely from bones and elves, but it's a world that's fundamentally separate from the world we inhabit. No perception that you see through VR is what's outside of that headset. You're totally immersed. It's therefore a tech for totally immersive experiences — escapism like movies or games.

AR, by contrast, focuses on the real world as the base, and builds on top of it. AR generates virtual items in this world by either using a mess of sensors to ensure they're correctly placed on its surfaces, or ignoring them completely and placing it on a much nearer plane. Though this sounds easier, as you don't have to generate an entire world, there are technical challenges that make versions of it as hard — but as valuable — as VR.

AR isn't all that good for immersion, because the real world is always there in the background. However, that also means it's excellent for anything that involves augmenting the real world. Voice calls, advertising, mapping, social networks... or even what Tim Merel of Digi-Capital calls "a-commerce". Yes, augmented shopping.

There are degrees of augmentation, of course. Device-led AR, where the

AR is imposed on a screen that's distant from the viewer, is a mediated reality that allows developers to more simply judge the environment. At its simplest, it acts as a head-up display (HUD) that sits over the scene like a 3D movie title sits on its background. This basic tech is the level that firms such as advertising innovators Blippar or Aireal use. It simply uses your existing device and an app, and imposes a new image on an existing scene, such as putting an animation of a football player near his promotional merchandise.

At a slightly more advanced level, this tech can detect a surface or shape in the environment and use that as a marker to estimate relative depths in the scene. You'll have AR apps that use special 'fiduciary marker' cards to anchor their sim, and allow the app to scale and rotate a virtual simulation to fit the environment.

The more VR-like AR requires a lot of extra tech. You need to be able to track the position of the viewer's head and their eyes, and judge relative distances, to make the illusion of something virtual be convincing. Most of these AR devices use a head-mounted display (HMD), which is a headset supporting a display device (or two) in front of the user's eyes. The sort of HMD we're interested in also tracks head position along six degrees of freedom — that means three components of translation (up/down, forwards/backwards, left/right) and

three components of rotation along those axes.

There are more extreme techs in development as well. Two different sets of contact lenses are in development: one academic, one military. The military ones are called iOptik and function much like bifocal lenses, with the twist that they're designed to work only with AR goggles. These contact lenses will allow humans to focus both on the background scene and the HUD on the goggles at the same time. Though they're being developed for the US Department of Defense, the company behind them hopes it can sell them as consumer products soon.

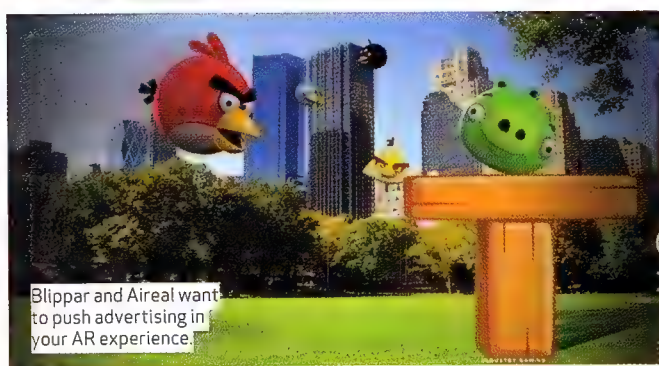
The more interesting academic tech comes from the University of Washington and is a set of 'bionic' contact lenses powered by radio waves and with LED displays built in. (The microfabrication process that means they self-assemble their circuitry using osmotic pressure is fascinating and totally irrelevant.) At the moment, the lenses have only been tested on rabbits, so it's still at an early stage and there are questions about the quality of the images it produces. Still, it's an impressive idea.

Of course, this is all minor stuff, mostly built in the hope that the big tech firms will buy out the company behind it. What's of greatest interest now is what those firms are focusing on, and what they think they can do with it.

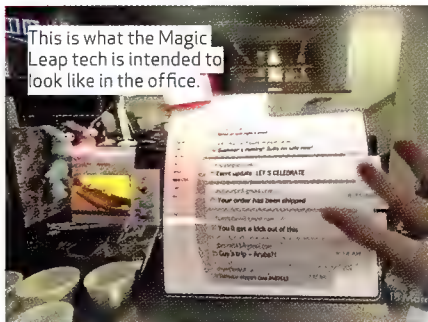
The Google-funded Magic Leap team includes superstar SF novelist Neal Stephenson.



Magic Leap works by projecting a display straight onto your retina.



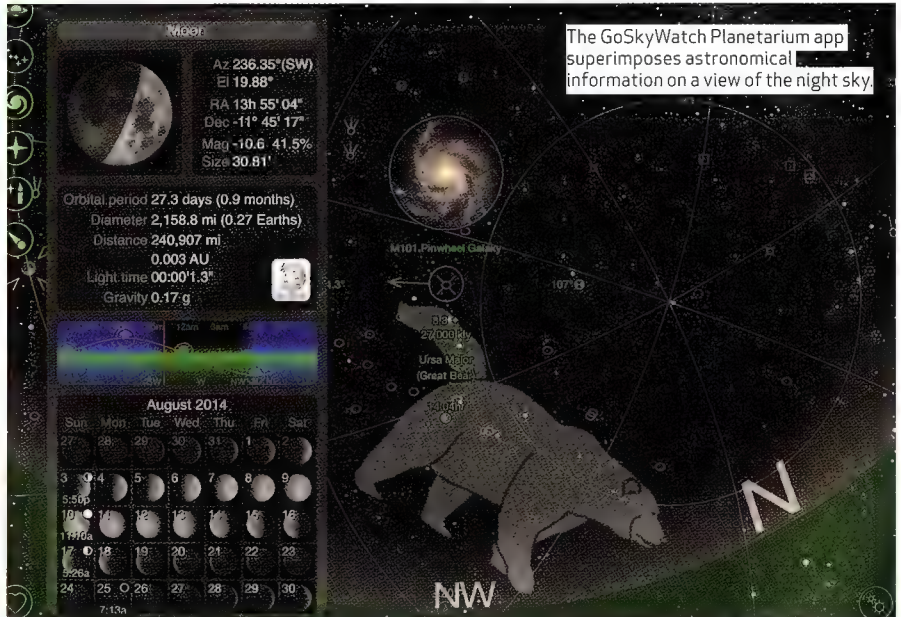
Blippar and Aireal want to push advertising in your AR experience.



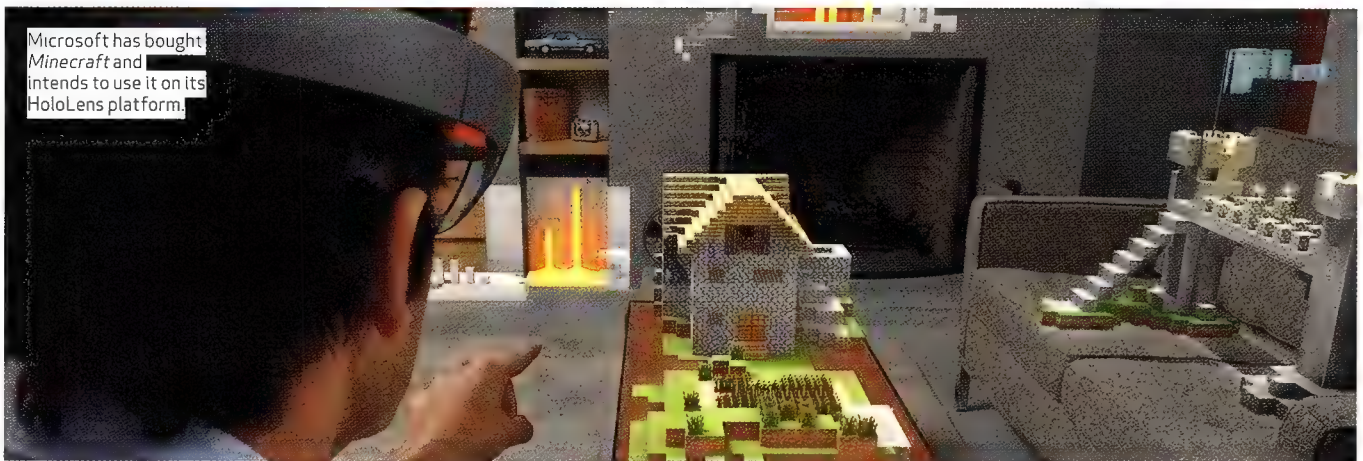
This is what the Magic Leap tech is intended to look like in the office.



A Magic Leap priority is being safe for kids.



The GoSkyWatch Planetary app superimposes astronomical information on a view of the night sky.



Microsoft has bought Minecraft and intends to use it on its HoloLens platform.

VALVE'S BLOWN OUT

The most interesting thing about Valve's AR offering is that it's actually no longer Valve's AR offering. After a Night of the Long Nerds in 2013, Valve released 25 people, including its entire AR team, we presume to focus on VR. The two AR project leads were given Valve's permission to do whatever they liked with the tech they'd made, which they've called castAR. They've created a company called Technical Illusions to finish off the development.

castAR is a bit different from other AR. It consists of a pair of polarised glasses with built-in projectors and

cameras, and a separate retroreflective surface studded with infrared LEDs. The camera uses the LEDs to track your head movement, so it can adjust the images that the projectors cast onto the surface. This means each polarised lens gets a different, yet coherent, image. Low latency lets you do things like look around an object. In other words, it projects a self-contained virtual reality into the real world.

As a result, it's used for static purposes rather than something more mobile, like the existing Samsung Gear VR and Nintendo 3DS. castAR's pitch video focuses on uses including

previewing 3D architectural blueprints, playing 3D board games remotely on unexpected surfaces, creating 3D presentations, and just for use as a 3D desktop PC. As long as you put that retroreflective material all over your house.

MICROSOFT DOES EVERYTHING

You've almost certainly heard of Microsoft's contribution to the AR party – its HoloLens system for Windows 10 and possibly Xbox One. It seems revolutionary, but its use of the word 'holographic' might be suspect (and mainly due to affection



CastAR's prototype is the ugliest, but also the lightest-looking of the devices.



It's striking how many of these headsets hark back to kid's toys like the View-Master.



Sony's SmartEyeGlass is basically Google Glass, at half the price and with slightly worse software.

for *Star Trek's* Holodeck). Kinect seemed revolutionary in the hermetic demonstration settings you get at big tech trade shows.

HoloLens definitely looks impressive from the screenshots scattered around these pages. It's a futuristic headset that superimposes 3D creations into the world and allows you to interact with them. The impressive element here is how high-quality the images they produce are – from the videos and reports, it's utterly compelling, if nowhere near as immersive as the HTC Vive or the Oculus Rift.

The actual headset is a lot bulkier than a comparative AR headset, Google Glass, for example, but then this has the power of a true VR headset because it's not doing a simple 2D overlay. It reportedly weighs around 400g, is adjustable to all head sizes and is totally wireless. It consists of holographic lenses, depth cameras and three separate processing units: one central, one graphics and one holographic.

The depth cameras are built from the same tech as Kinect, but are lower power, have a wider viewing angle and are placed around the front and sides of the headset. They track both the user's head and hands, as HoloLens is controlled entirely by gesture and voice, *Minority Report* style. This lets you interact with the 3D virtual models of the apps, from building blocks in *Minecraft*, to sculpting the bodywork of a motorbike. Microsoft is working on 'pinning', which will let you stick these models in place in the environment, so you can move around them, and 'holding', so you can pick them up and manipulate them.

The apps are really what wowed the press when HoloLens was announced. Microsoft recently bought *Minecraft* for US\$2.5 billion, and it's already made a version of it that runs on HoloLens. NASA has an app that lets you explore Mars, and there's a version of Skype that runs on it so that a builder can explain to you why you should have spent more time in woodwork at school.

Though the reports are mostly positive, the tech was in an early stage, and there were concerns over whether the hardware could fit into a consumer unit, and the regularity with which the illusion was broken.

However, that's not all, as Microsoft also has several other AR and VR projects under way. It definitely has an AR headset ready to go – Microsoft bought the smart glasses firm Osterhout Design Group in March 2014. And another project called RoomAlive was shown off in October 2014, consisting of a set of projectors that transformed the walls of an entire room into an interactive environment.

Digressing for a moment, there are

also persistent rumours about a VR headset for Microsoft's Xbox One games console. After all, *The Wall Street Journal* said in March 2014 that the firm already had 3D virtual reality tech ready to go. HoloLens has reduced the chances of that coming to market, but we assume Microsoft has it ready as a backup.

GOOGLE DOES IT BETTER

Google Glass was the company's high-profile effort in the field of AR, and you might argue it was its first high-profile failure, given that Glass has currently been removed from sale ahead of a redesign and a new model. The device is a set of (quite pretentious-looking) plastic and metal glasses, with a HUD projected onto it and a smartphone-like processor behind it all, which was on sale for US\$1,500.

Glass did everything you thought it should, like understand natural voice commands, record video, take photos, and all the update elements of your phone. It had a small touchpad on the side of the device, which let you browse a timeline of recent events. The screen was a Liquid Crystal on Silicon (LCOS) device with an LED-illuminated display that used polarisation and reflectors to bounce the image into your eye. It had a wide range of supported Google apps, including Now, Gmail, Maps and Google+. But it's now on a hiatus while a new version is being designed.

That's not all of Google's AR efforts, though. It's also making simple AR games for its Android phones, such as *Ingress* – a massively-multiplayer location-based game built on Google Maps. It also has Project Tango in the wings. This is a standard tech for mobile devices that allows them to navigate the physical world in the same way we inefficient meat-bags do. It uses advanced computer vision, image processing and special image sensors to make an end-to-end navigation tech that understands its own 3D motion in the world, it can perceive depth, and it can use visual cues about areas or objects they know to constantly self-correct. At the moment, it's only available to core developers, but we assume it'll be integrated into next-gen Android hardware.

Magic Leap (www.magicleap.com) is yet another Google-funded project, coming in at US\$542 million, and a direct challenge to Microsoft's HoloLens. This is being built by a team of tech and games industry veterans, including the author Neal Stephenson and the 3D team at WETA, who made the *Lord of the Rings* special effects. Reports have it as more believable and solid than Microsoft's HoloLens. It works using a virtual retinal display; that is, a display projected straight onto the retina itself.



Microsoft's Kinect was disappointingly under-used.

Try AR today

There are many older ways to try AR today. As it's a more mature technology, there are some basic devices that take advantage of it already, as well as many mobile phone applications to try. For example, the Carl Zeiss VR One headset supports AR features and will work with any iOS or Android headset between 4.7 and 5.2 inches. Google Glass has now been cancelled, but that's out there, too.

There's a huge array of AR apps for mobile phones. One of our favourites is GoSkyWatch Planetarium for iPhone and iPad. This is one of many stargazing apps that use the device's accelerometer and GPS to orient your device, so wherever you're pointing, it shows constellations, stars and nebulae. See also Anatomy 4D, Google Goggles (which can translate text on the fly), Field Trip (which lets you know about nearby attractions), and iOnRoad Augmented Driving, which gives speeding alerts, crash warnings and driving analytics to drivers.

The PlayStation Vita has AR features, and comes with a package of free AR games, such as *Table Ice Hockey* and *Pulzar*. Similarly, the Nintendo 3DS comes ready-loaded with AR Games and six AR cards. Every game is super-imposed on the real world, but has no interaction with it – it's more of a gimmick.

If you've got a PS3, you could pick up a Wonderbook. It was a *Harry Potter*-inspired AR tome with blank pages that only filled when viewed on your TV through the PlayStation Eye camera. Similarly, the PS4 has Playroom, a much smoother AR sandbox where you can play with small robots that are running around your lounge. Kids love it.

You can also try the Kinect system, on both Xbox 360 and Xbox One. While it never got the backing it deserved from developers, it has a uniquely detailed depth camera that means it can track your entire body shape – or several in the Xbox One's case – on-screen. It's probably the most advanced consumer AR tech available on the market today.

What about VR?

We've covered VR extensively in the past, but it's worth giving you a quick status update as to where the tech is today. There are three projects that are nearing release. Sony's Project Morpheus, Valve and HTC's Vive, and Facebook's Oculus Rift.

Of these, Oculus Rift is the oldest and several developer iterations have been released. A cut-down version of it made to work with Samsung mobile phones, the Samsung Gear VR, has already been released. It works by slotting a Samsung Note 4 or Galaxy S6 into a viewing device and runs with 1,280 x 1,440 on each eye and a 96° viewing angle.

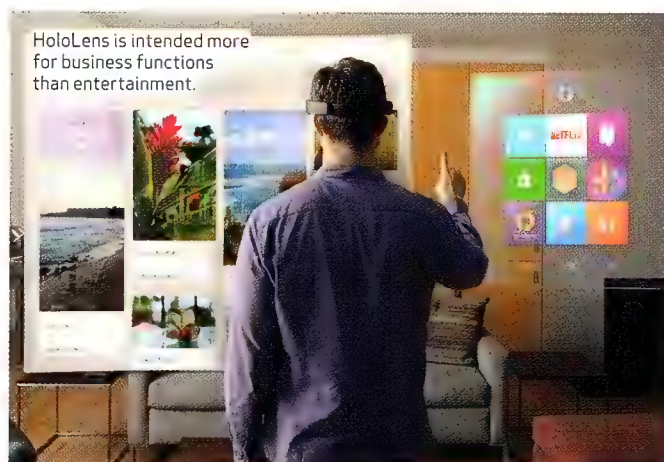
Despite that, there's still no sign of the Oculus Rift consumer model. The most up-to-date version, the Crescent Bay prototype, has a positional tracking camera for your head, low-persistence OLED display (to eliminate blur) and runs two screens at 960 x 1,080 on each eye, at 90Hz, and a 110° viewing angle. No official release date has been announced, but early 2016 is the current target.

Sony's Project Morpheus is the quickest developed of the three. Like its AR solution, Sony seems more concerned with getting a working version of its tech to consumers than with making it the cutting edge. The version we tried in July last year was much lower resolution and fidelity than the Oculus Rift versions we'd tried up to that point, but both companies have since substantially improved their hardware. It has a

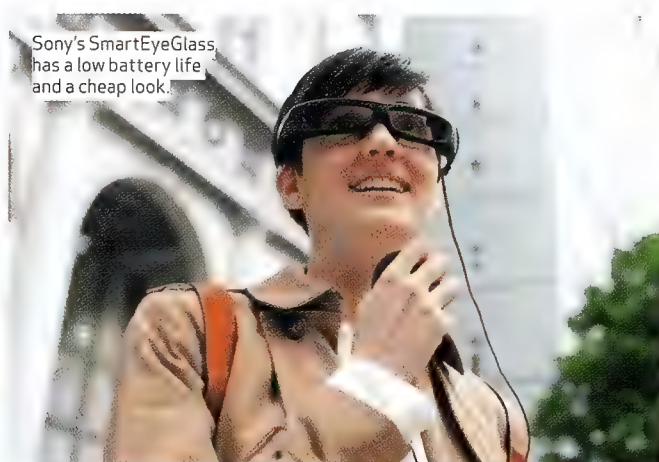
similar OLED screen running at 960 x 1,080 on each eye, a 100° viewing angle, and a 120Hz refresh rate. It was very comfortable, presumably because much of the hardware was sitting in a set-top box, not on our heads. It tracked our heads using the PlayStation camera, and it had true 3D audio. It's due out in early 2016 for PS4, which already has motion-sensitive controllers.

Valve and HTC's Vive headset is the most impressive. It recognises that some of the joy of VR is in interacting with those virtual worlds, so it does two things. First, it has a pair of bespoke controllers for you to hold, allowing limited interaction. Second, it has a set of cameras that sit in the corner of your room, detect your location and any obstacles, and track your movement, as well as setting the virtual world's limit at your real-world limit.

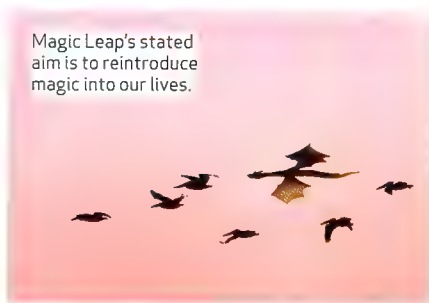
Vive has two 1,080 x 1,200 screens running at 90Hz. As the screens are narrower, you'll have a wider vertical field, and it should be lighter as your PC will do all the processing. Its big selling point is those two motion-tracking cameras, which are infrared and wireless, to follow the headset's 37 sensors. This enables you to roam freely in the virtual world. It works with multiple players and should be out this year. If you want to try VR today, you can get a casing for your mobile phone like the Google Cardboard, or a cheap third-party headset like the Immerse from Firebox.



HoloLens is intended more for business functions than entertainment.



Sony's SmartEyeGlass has a low battery life and a cheap look.



Magic Leap's stated aim is to reintroduce magic into our lives.



With US\$500 million in funding, Magic Leap can make any number of virtual seahorses.

Similar to HoloLens, the simulation looked utterly convincing. The animated 3D creatures it portrayed looked detailed and sharp, and sat well in the surrounding world. And similar to HoloLens again, it ran on a huge piece of hardware (essentially a PC) sitting nearby, rather than in the headset itself. It's worth looking at the promo video to see what it's capable of. Magic Leap hasn't really been announced or promoted yet, but we're expecting it to launch in 2016 or 2017.

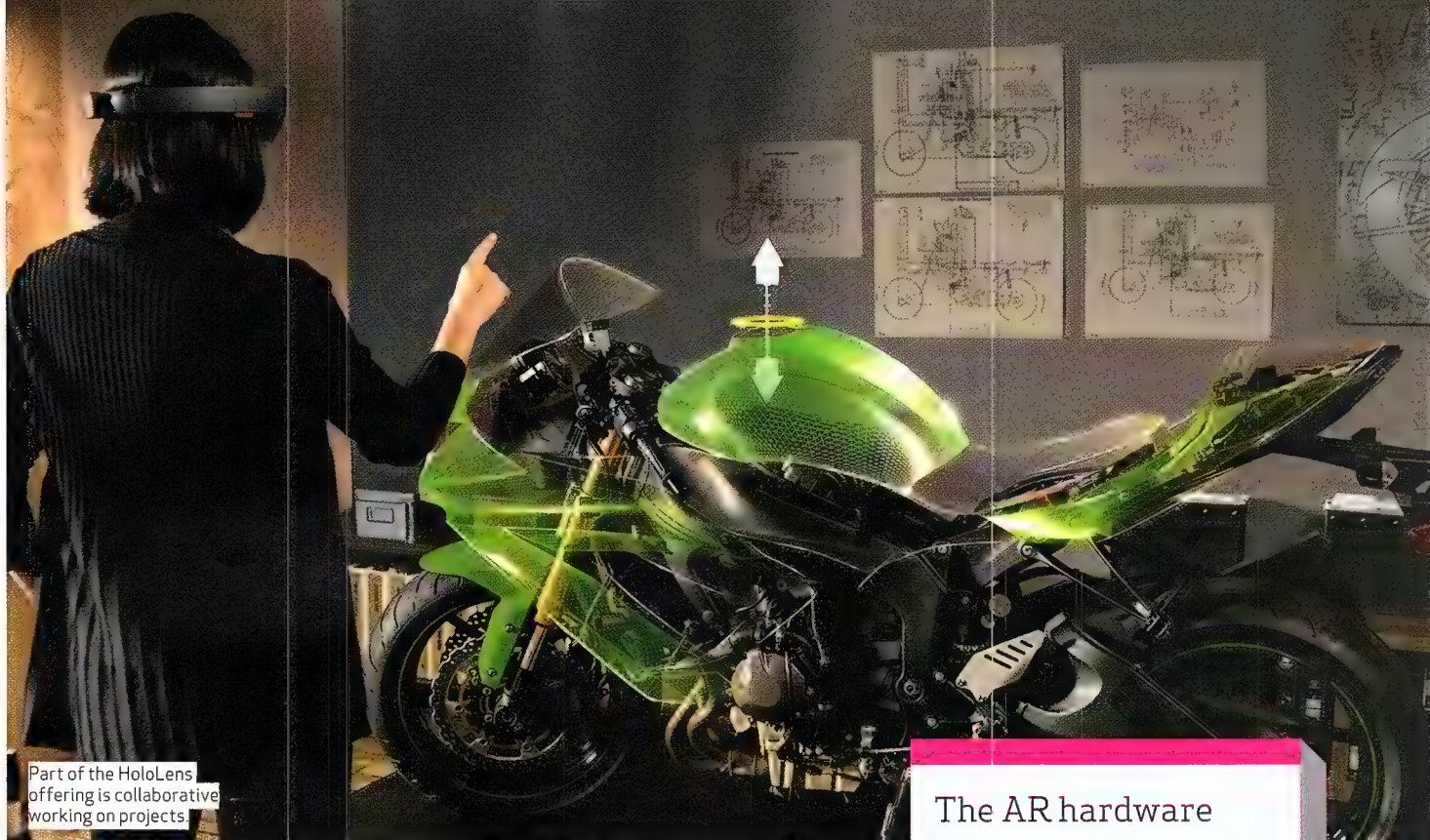
SONY'S 'ME TOO' TENDENCY

The Japanese giant always seems to want to get involved in any new tech, but recently it hasn't been leading the market here. Its Project Morpheus feels like a 'me too' VR solution, but it'll surely work well on PlayStation 4 and might actually sell well (see 'What about VR?' above). And it's

already experimented with AR in the form of The Wonderbook for the Playstation 3 (see 'Try AR today' on page 65).

However, SmartEyeGlass is Sony's foray into AR. The currently available SmartEyeGlass SED-E1 Developer Edition is very similar to Google Glass, although much cheaper at just US\$840. It uses 'holographic waveguide technology' in 3mm AR lenses, which produces something very similar to Glass, with overlaid green text and diagrams operating at 15fps. It also has a 3MP camera that can take both pictures or video.

It connects to compatible Android phones by Bluetooth and is controlled by a small, ugly-looking puck that sits on the user's lapel, which also doubles as microphone, speaker, NFC and battery – which comes in at only 150 minutes. At the moment, we'd stay away



Part of the HoloLens offering is collaborative working on projects.

from this device. It's ugly as sin, with a poor battery life and not many apps. Wait for version two.

APPLE OF THE EYE

There haven't been any official reveals of Apple's research into VR, but then Apple is more tight-lipped than a close-mouthed clam ahead of any announcement. Apple does have several patents for AR tech – there's a very interesting one for a 'transparent electronic device' that sounds very much like an AR device. Examples in the patent include using the device to overlay information about a museum exhibit. Interestingly, the device would be able to opaque itself, and only display selected elements of the background world, otherwise being a normal opaque LCD or OLED display.

That said, an analyst from the US investment bank Piper Jaffray (annoyingly but understandably, investment bankers get a lot more access to tech firms than journalists do) published a report in March saying he believes Apple has a small team experimenting with the AR space, but that they think consumer AR is still 10 years off. We'll see from Microsoft and Google efforts whether they're wrong – but they might be on the money when it comes to mass market success.

THE STATE OF THE ART

As that US\$120 billion valuation by Digi-Capital might indicate, there's a lot of hype around AR and VR at the moment. Hundreds of firms are trying out strange new tech to augment the sensation. For example, Bristol's UltraHaptics uses targeted ultrasound vibrations on a user's skin to form tangible shapes and textures from

thin air, so the users can feel them without the need for worn equipment. That, combined with the hand-detecting Leap Motion device, makes for delicately convincing sims, like brushing your hands over ghosts. For VR, we've seen every type of treadmill under the sun – giant balls, resistant pads, harnesses around the waist – anything to convince you that you're in the virtual world.

On balance, the hype is justified. It's not like the first tablets, when Microsoft launched them stillborn into the market. Too many big companies are competing here for this to not be a success for one of them. But challenges remain, and they're not insubstantial. The biggest are in shrinking the tech down to a headset, or headset and pack model, in maintaining persistent simulations while doing that, and in preventing object placement errors. It's likely that, after all of this experimentation, mobile phones will be the first devices that give us a taste of this. As always in that field, Apple will be the firm to watch. That said, Google's Magic Leap investment is considerable enough and the tech advanced enough that we'd cautiously predict it'll be first to market, albeit in a reduced form.

One prediction we're happy to make is that in 20 years' time we'll be looking back at this, the way we now look back at the first mobile phones. This technology is going to revolutionise many things – anything that requires 3D knowledge, such as architecture or warehouse management; anything that requires the management of large data sets, like programming; and anything that just wants to look pretty, like art or video games. We just have to wait for the hardware to catch up.

The AR hardware

Not all AR devices share the same hardware and software, but there are some basic technology aspects they do need. First off, you need a processor to work everything out, a transparent display to show the world and the projections, a light power source, plus a variety of sensors and input devices.

The sensors can take several forms, but are mostly included as standard in mobile phones. An accelerometer lets you measure impetus, a GPS measures global location, and a magnetometer or solid-state compass measures the device's orientation against the Earth's gravitational field; that is, the ground. Luckily, modern smartphones contain all of those things.

For AR technologies that aren't based on mobile phones, if you want all these elements, they have to be built in, which can increase the size and cost of the device substantially. If you choose to go without them, you'll lose a huge amount of functionality. It's notable that Sony's AR glasses system has a relatively large external box clipped to the user's lapel, while both HoloLens and Magic Leap have been demoed with large tabletop external units that were actually running the tech.

Input systems are another challenge. Unlike with VR, the user can see their hands, so a keyboard is an option. But also unlike VR, AR encourages users to be mobile. You want to look around the object and touch it, so you want your hands to be either free or holding interactive objects (like Valve's twin pointers). That means the device has to be wireless and the interface has to be voice, gaze or mediated touch. ■

WINDOWS 10: GOOD FOR GAMES?

Windows 10 brings more than an UI overhaul to the Windows franchise, it also has a lot going on under the hood, too. Ashton Mills takes a peek at how this impacts gamers, and answers the question: is it good for games?

Lets get this out of the way first to save you from the suspense: the answer is... kinda. You may have already heard of the impressive performance gains DirectX 12 (or more specifically, Direct3D 12) provides, delivering some genuine and badly needed innovation in the graphics space by revamping the API to take full advantage of our multi-core CPUs and parallel-natured GPUs.

Which is nice. But that's only for DirectX 12 titles, for which none are currently available. What about current games? Is there a benefit in upgrading to Windows 10?

In theory, there should be: to facilitate the impressive performance boost of Direct3D 12, Microsoft had to make changes to the Windows kernel and Windows display driver model (WDDM), optimising the rendering path to reduce latency and get developers 'closer to the metal'. Since some of these improvements are

independent of Direct3D 12, we had hoped to see Windows 10 providing a small boost to all games over Windows 8.1. But after putting Windows 10 through its paces in the APC labs, that isn't quite what we're seeing.

First, however, lets take a look at what Windows 10 brings to the table.

DIRECT3D 12

As with any DirectX release the latest version brings with it a number of new features, the most important is the overhaul to the rendering pipeline.

COMMAND LISTS

Whereas DirectX 11 is limited to pushing draw-calls through a single thread, Direct3D 12 splits this load among as many CPU cores as you have. To do this, commands – which contain draw and resource management calls – are bundled into independent lists that can be threaded across multiple cores. Additionally, GPUs are highly parallel by nature, and whereas

previously the GPU processed calls as they were received, with command lists the GPU can unpack the list and process all the commands in parallel, further boosting performance.

EXPLICIT MULTI-ADAPTER

This parallel nature is extended to another new feature called Explicit Multi-Adapter – here DX12 can utilise multiple independent GPUs to spread the workload. This could be thought of as similar to SLI or Crossfire, except unlike these proprietary technologies, DX12's Explicit Multi-adapter can utilise GPUs of differing make and model, for example mixing an Nvidia and AMD GPU. More directly, this will allow you to utilise the on-board graphics of recent Intel CPUs alongside your independent GPU.

POOLED MEMORY

In a similar vein, VRAM across multiple GPUs can be pooled and

shared. For example two 4GB cards providing a total of 8GB, compared to current SLI and Crossfire systems where each GPU's memory has a copy of the same data. This is an obvious boon for VRAM limited scenarios, such as 4K gaming, but it remains to be seen how effective this will be – afterall, the PCI-E bus is considerably slower than the memory interface GPUs use to their on-board RAM, but the overhead may be the preferred option instead of hitting a VRAM limit.

For more details on the changes in DirectX12 see Microsoft's official DirectX blog at blogs.msdn.com/b/directx.

SNEAKING A PEEK AT PERFORMANCE

While there are no DirectX 12 titles at the time of writing, we do have one test which can provide an insight into the performance advantages of the Direct3D 12. 3DMark's DX12 API test attempts to push as many draw-calls as possible in both Direct3D 11 and Direct3D 12, allowing us to see how Direct3D 12 accelerates performance by splitting up the load across CPU cores.

As you can see, on our Sandybridge 3970X and GTX 680 test system DirectX 12 facilitated a stunning 7-fold performance increase. But while impressive it's important to note this is just a draw-call throughput test – you won't be seeing this much of a jump in actual games. In practice, especially with newer DirectX 12 games and the graphical fidelity they will bring, your GPUs will be plenty busy just trying to render a scene. However, for the first time, your CPU will no longer be a bottleneck in those instances where the GPU was waiting on the CPU to prepare frames.

The good news as well is that you won't need the latest whizz-bang GPU to take advantage of these features. Nvidia GPUs from Fermi (GTX 400/500) onwards and AMD GPUs from GCN 1.0 (Radeon 7000/8000/200) onwards will support these core changes, though the finer levels of DX 12 feature support (such as Tier 2 Resource Binding and Conservative Rasterization) will remain the domain of the latest cards.

WINDOWS 10 GAMING

The changes Windows 10 brings are impressive for DirectX 12 titles, but how does it perform with current-

"Whereas DirectX 11 is limited to a pushing draw-calls through a single thread, Direct3D 12 splits this load among as many CPU cores as you have."

METRO LAST LIGHT	
1080P - MIN FPS	
WINDOWS 8.1	36
WINDOWS 10	30
1080P - AVG FPS	
WINDOWS 8.1	97
WINDOWS 10	100
1080P - MAX FPS	
WINDOWS 8.1	240
WINDOWS 10	252
1600P - MIN FPS	
WINDOWS 8.1	26
WINDOWS 10	27
1600P - AVG FPS	
WINDOWS 8.1	60
WINDOWS 10	60
1600P - MAX FPS	
WINDOWS 8.1	133
WINDOWS 10	132

TOMB RAIDER 2013	
1080P - MIN FPS	
WINDOWS 8.1	90
WINDOWS 10	86
1080P - AVG FPS	
WINDOWS 8.1	122
WINDOWS 10	122
1080P - MAX FPS	
WINDOWS 8.1	164
WINDOWS 10	172
1600P - MIN FPS	
WINDOWS 8.1	52
WINDOWS 10	52
1600P - AVG FPS	
WINDOWS 8.1	73
WINDOWS 10	74
1600P - MAX FPS	
WINDOWS 8.1	94
WINDOWS 10	94

BIOSHOCK INFINITE	
1080P - MIN FPS	
WINDOWS 8.1	48
WINDOWS 10	40
1080P - AVG FPS	
WINDOWS 8.1	152
WINDOWS 10	125
1080P - MAX FPS	
WINDOWS 8.1	426
WINDOWS 10	515
1600P - MIN FPS	
WINDOWS 8.1	41
WINDOWS 10	38
1600P - AVG FPS	
WINDOWS 8.1	100
WINDOWS 10	78
1600P - MAX FPS	
WINDOWS 8.1	442
WINDOWS 10	418

SHADOW OF MORDOR	
1600P - MIN FPS	
WINDOWS 8.1	62
WINDOWS 10	55
1600P - AVG FPS	
WINDOWS 8.1	97
WINDOWS 10	92
1600P - MAX FPS	
WINDOWS 8.1	168
WINDOWS 10	181
4K - MIN FPS	
WINDOWS 8.1	38
WINDOWS 10	36
4K - AVG FPS	
WINDOWS 8.1	53
WINDOWS 10	49
4K - MAX FPS	
WINDOWS 8.1	61
WINDOWS 10	62

DRAGON AGE INQUISITION	
1080P - MIN FPS	
WINDOWS 8.1	105
WINDOWS 10	88
1080P - AVG FPS	
WINDOWS 8.1	135
WINDOWS 10	105
1600P - MIN FPS	
WINDOWS 8.1	70
WINDOWS 10	56
1600P - AVG FPS	
WINDOWS 8.1	83
WINDOWS 10	65

TALOS PRINCIPLE	
1080P - AVG FPS	
WINDOWS 8.1	136
WINDOWS 10	138
1600 - AVG FPS	
WINDOWS 8.1	96
WINDOWS 10	98

ALIEN ISOLATION	
1080P - AVG FPS	
WINDOWS 8.1	164
WINDOWS 10	180
1080P - MAX FPS	
WINDOWS 8.1	308
WINDOWS 10	280
1600P - AVG FPS	
WINDOWS 8.1	103
WINDOWS 10	109
1600P - MAX FPS	
WINDOWS 8.1	221
WINDOWS 10	135

"As you can see, on our Sandybridge 3970X and GTX 680 test system DirectX 12 facilitated a stunning 7-fold performance increase."

Will it run?

WINDOWS 10 REPRESENTS ANOTHER IMPORTANT CHANGE. MICROSOFT GETTING SERIOUS ABOUT WHAT IT ALLOWS ACCESS TO AT A DEEPER LEVEL. THIS HAS BROKEN SOME ANTI-VIRUS SOFTWARE AT THE TIME OF WRITING, BUT ALSO HAS ANOTHER SIDE EFFECT: OLDER GAMES USING SECURUM OR SAFEDISC DRM WILL NO LONGER WORK.

On the one hand it could be seen that the fact these widely reviled DRM mechanisms won't work is a good thing, but on the other it leaves you in the lurch if your game uses one of these methods.

It also provides the platform for a bitter irony — you can still play these games on Windows 10, if you crack it by downloading a pirated .EXE with the DRM removed.

Considering most publishers of older games abandon them, this may be the only way you'll be able to play a game you paid for.

generation games, on mainstream hardware? If you have a reasonably recent machine — Haswell based and anything from a 780Ti or AMD equivalent and up, there's a good chance your games will run well regardless.

But what if your PC is a little older? Will the changes in Windows 10 give you a boost in your favourite games over Windows 8.1?

To answer this we put Windows 10 through a battery of tests with a mid-range system based on Nvidia GTX 680 4GB cards using an overclocked 4.5GHz 6-core 3970X to ensure the CPU won't be a bottleneck. Although DirectX 11 and prior doesn't multi-thread like DirectX 12, it will allow a game's own multi-threaded processing to not be limited in our tests. The 4GB on-board the GTX 680s also ensures we wouldn't be bottlenecked by VRAM in a game, especially at the two 4K tests.

We tested both single-card and two-card SLI configurations in a range of resolutions to allow Windows 10 to stretch its legs. Interestingly, we found that the percentage of

performance difference — be it positive or negative — between Windows 8.1 and Windows 10 was the same in both single-card and SLI, but we'll display the SLI results as these show the differences a little clearer. Driver version for both operating systems was 353.62.

RESULTS ANALYSIS

As usual minimum and maximum frames per second are the most important metrics, and usually we wouldn't include max FPS as they can reflect simple spikes from low-demand areas of the benchmark that aren't indicative of overall performance. However they're useful here precisely because we're comparing the throughput of Windows 10, and in some cases the maximum can reveal efficiencies or bottlenecks due to the OS.

3DMARK AND VALLEY

3DMark is a good test as it makes use of all the latest features of a DirectX API, though due to its popularity GPU vendors tend to ensure drivers are optimised for it. Here then it's no surprise that the performance is the same between Win 8.1 and Win 10, the one exception being the Skydiver test where Windows 10 is slightly ahead. We ran this precisely because it's a benchmark designed for lower-end systems, and as a result the GPUs won't be the bottleneck. Instead the CPU and OS will be pushed to deliver frames as fast as they can. We can see the difference in score, though small, may be showing some of the under-the-hood performance improvements we're looking for.

Unigine's Valley is a great test as well, allowing us to compare DX9 and DX11 output on the same benchmark. Here however Windows 10 scores noticeably worse than Windows 8.1 for the low-res DX9 test, but manages to keep up for the more demanding high-res DX11 test.

3D MARK

3DMARK	FIRESTRIKE ULTRA (4K) - OVERALL SCORE
WINDOWS 8.1	3415
WINDOWS 10	3414
3DMARK	FIRESTRIKE ULTRA (4K) - OVERALL SCORE
WINDOWS 8.1	6513
WINDOWS 10	6468
3DMARK	FIRESTRIKE ULTRA (4K) - OVERALL SCORE
WINDOWS 8.1	12256
WINDOWS 10	12239
3DMARK	FIRESTRIKE ULTRA (4K) - OVERALL SCORE
WINDOWS 8.1	31094
WINDOWS 10	31746

3DMARK DX12 API TEST

DX12 API TEST	OVERALL SCORE
DX11 SINGLE THREAD	2,333,684

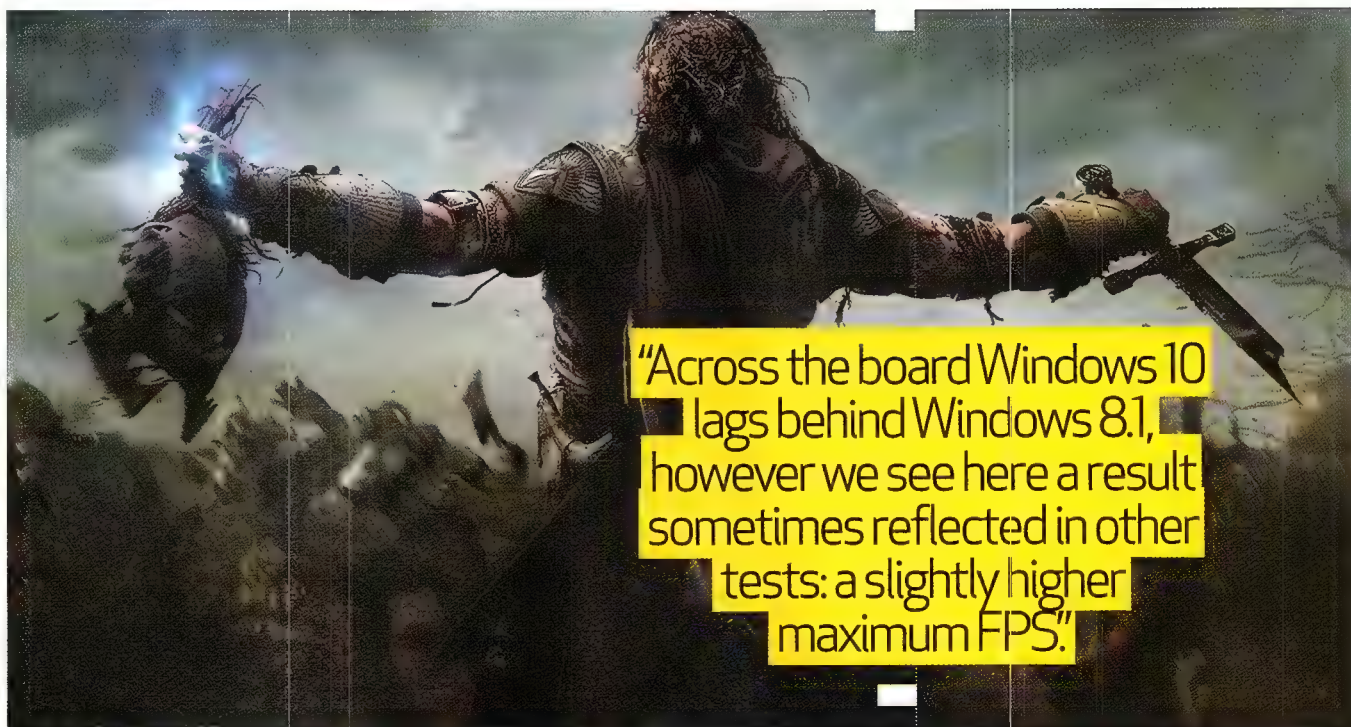
DX12 API TEST	OVERALL SCORE
DX11 MULTI THREAD	2,256,048

DX12 API TEST	OVERALL SCORE
DX12	15,107,573

UNIGINE VALLEY BASIC DX9

UNIGINE VALLEY	BASIC DX9 (720P)
WINDOWS 8.1	5418
WINDOWS 10	3858

UNIGINE VALLEY	EXTREME HD DX11 (1080P)
WINDOWS 8.1	4762
WINDOWS 10	3827



TOMB RAIDER

Windows 10 had a slightly higher consistent maximum in all tests by a few frames in 1080p, but the difference disappeared at the higher 2,560 x 1,600 resolution, indicating the bottleneck was more on the GPU side. Generally, it performed the same on both operating systems.

THE TALOS PRINCIPLE

Here Windows 10 consistently had a slight edge over Windows 8.1. This game and *Alien Isolation* were the only two cases where Windows 10 was ahead.

SHADOW OF MORDOR

Here we tested a minimum resolution of 2,560 x 1,600 and upped this to 4K for the second test. Across the board Windows 10 lags behind Windows 8.1, however we see here a result sometimes reflected in other tests: a slightly higher maximum FPS. This again could be a reflection of Windows 10's optimised rendering path when the GPU is waiting on the CPU.

BIOSHOCK INFINITE

Across the board Windows 10 performs worse than Windows 8.1. The minimum is especially jarring at 1080p, but as with some of the other benchmarks we see this difference reduce as resolution increases. This is really starting to show that as GPUs become the bottleneck, differences between the operating systems fade away.

DRAGON AGE INQUISITION

Another title where Windows 10 is flat out slower in both the important



Direct3D 11 vs Direct3D 12 rendering path. Source: Microsoft.

metrics of minimum FPS and average FPS. Not much else to say here.

ALIEN ISOLATION

Along with *The Talos Principle*, this shows an improvement with Windows 10. In both cases however the maximum FPS was greatly reduced, though this is less important. *Alien Isolation* is a great test as it also reports frame times, and here the average frame time was ever so slightly faster on Windows 10, which is what we'd expect and hope to see given the rendering path optimisations. However, when seen as a whole with the game, the overall increase in performance is mild.

METRO LAST LIGHT

Aside from a consistently lower minimum at 1080p in Windows 10, which isn't the best result, the scores across the board are that the game performs about the same. Again as we raise resolution, differences between Windows 8.1 and Windows 10 become smaller as the bottleneck moves to the GPUs.

SO, GOOD FOR GAMES?

Kinda. Across our benchmarks we have four titles that are slower

(*Valley*, *Shadow of Mordor*, *Bioshock Infinite*, and *Dragon Age Inquisition*), three that are about the same (*3DMark*, *Tomb Raider*, *Metro Last Light*), and two that are faster (*Talos Principle*, *Alien Isolation*). It's a mixed bag of results, erring slightly on Windows 10 not coming up to par.

Now on the one hand you can say Windows 10 is new and there are always teething problems. But don't forget Microsoft developed Windows 10 using an open beta process with millions of users, and GPU vendors like Nvidia and AMD have had access for well over a year to develop drivers alongside the new OS.

Whether the slow-downs we've seen here are a function of the OS or drivers isn't clear, and it's worth noting these tests were only with Nvidia hardware. Inevitably both Microsoft and Nvidia will continue to refine performance. Ultimately though, except for those power users with 144Hz displays, as long as you can reach a consistent 60fps as a minimum you'll have a pleasant experience. And that's the salient point – if you've got enough grunt in your PC to do this then you've got no worries, but if you're struggling to meet 60fps in your games right now you might want to hold off until the OS and drivers have matured a little more. ■

how to

» QUICK TIPS

Experts solve your computing problems

APC and its readers can be one giant helpdesk. If you have a technical problem, chances are one of us can solve it.

HARDWARE

CONVERTIBLE DRIVE

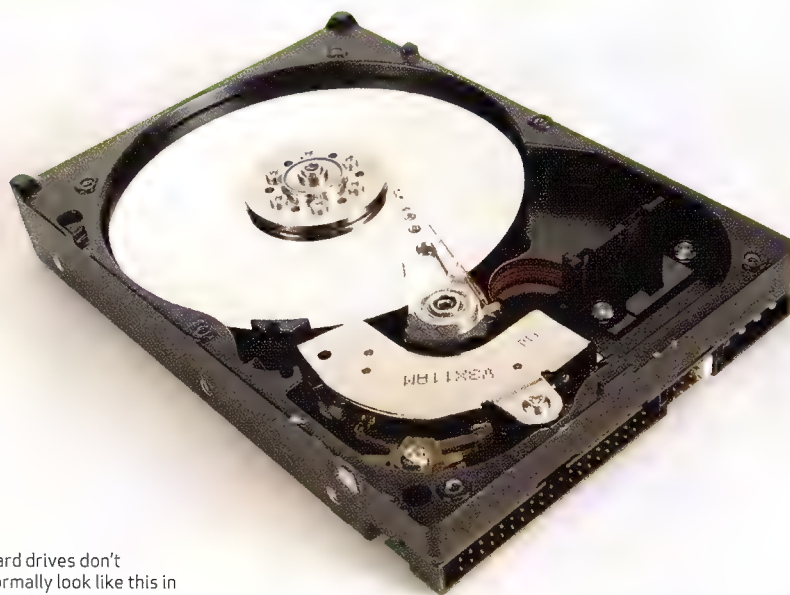
I'm looking to replace the hard disk in my somewhat oldish desktop computer, to give it a bit more pep. I've been looking on various other sites and I notice a lot of drives seem to have their innards exposed. Are these 'naked' drives designed for laptops with sealed cases or will they work in a normal desktop case? I'm sure I've heard in the past that dust is bad for disk drives, and the inside of my case has more than enough of that to cause problems if that is true.

Keith Derby

Dust is very, very bad for hard disk platters. The read/write heads of a hard disk fly about 3 nanometers above the surface. The smallest dust particles are about 1 micron, which is 300 times bigger. In a 7,200rpm drive with 3.5-inch platters, the heads are travelling at 120km/h around the outside tracks.

Now, the mass of a grain of dust is trivial compared to the momentum of the drive heads, but it can interfere with the flow of air that provides the aerodynamic lift keeping the head at the right separation. The turbulence can be enough to cause the heads to wobble in flight and crash into the surface of the platter. This gouges a big scrape in the media coating, and permanently destroys that track.

Or at least it would, if the hard disk wasn't factory-sealed into a box with just a single, highly filtered vent hole to equalise changes in atmospheric pressure. All hard disks remain sealed like this for the whole of their working life. The only time you will ever see the heads and platters is when someone destroys a disk by taking the lid off for a publicity shot. If I look at the web page for Taronga Zoo Tigers (taronga.org.au/animal/sumatran-tiger), in case you were wondering) the tigers



Hard drives don't normally look like this in real life.

don't appear to be enclosed either, but I'm pretty sure they are.

Luis Villazon

MAC

OS X ACTIVITY MONITOR ALTERNATIVES?

I've owned a Mac for less than three weeks, and after using Windows for over 10 years I got used to fiddling around 'with the hood up'. Windows 8 has some very useful reporting and monitoring tools built into Task Manager. So far in OS X there doesn't seem to be anything in the same league; Activity Monitor only offers extremely limited graphing. Is there anything I've missed?

Alan Portman

Activity Monitor is as good as it gets in the default OS. There are third party utilities that offer prettier graphs – Stater (\$6.49, App Store), iStat Menus

(US\$18, bjango.com) and MenuMeters (free, ragingmenace.com), for example. However, installing them isn't always the best idea. More data is not the same as more information. Don't be fooled by pretty graphs into thinking that the data presented is useful. I have iStat Pro on my dashboard, but I never use it. Few of the dozens of problems we encounter for readers are solved by using these tools. I can imagine scenarios where I might need them (hence me leaving iStat Pro installed), but in practice I rarely do. If I don't need them, you probably don't either. Bear in mind this is something we recommend for Windows users, too! If you run low on disk space, then it can be helpful to know which files and folders are taking up the most space. I use DaisyDisk (\$12.99, App Store). But I don't run it unless my disk is getting full. I use Activity Monitor to see if anything's chewing up my bandwidth, but nothing fancier than that.

Luis Villazon

CODING

LOGGING LESSON

At work, we have some old servers running Windows NT that do some environmental



iStat Pro has lots of exciting numbers, but it's very rare that you'll actually need them for anything.

systems monitoring for some of our equipment. These servers have log files that record the values from some sensors and any remote queries that have been made by our engineers. One of my 'morning coffee tasks' is to clear out those log files because if they get too big, the system crashes. I can't delete the files completely — I have to open each one, hit Ctrl-A, Ctrl-X, Ctrl-S, and exit. Is there a way to automate this?

Amun Habekost

You can do this from the command line or a batch file. Something like `FOR /R N:\FolderName %%f IN (*.LOG) DO TYPE NUL > %%f` ought to do it. Replace N:\FolderName with the networked drive letter and path, and save that in a text file as `deletelogs.bat` on your desktop. If there are logs in more than one folder, you'll need a FOR command for each folder.

But the bigger picture, of course, is that your company is using ancient servers connected to dreadful logging software and this solution isn't going to help with that. The way to convince your company to upgrade is to make clearing the log files harder, not easier. That way, you can point to the time it takes you to clear them every day, multiply it by your salary and show that over a year they would save money by installing new hardware. For that you need to delete those logs as slowly as possible. I'd suggest disabling autorepeat on your keyboard and backspacing each character one at a time. This will also let you add in the wear and tear of your keyboard as part of the potential cost savings.

Luis Villazon

WINDOWS

COMPRESSION MAKES THINGS BIGGER!

I have a PC with a 1TB hard disk that is starting to run low on space. A lot of this is taken up with various VMware clients I don't use much any more, so to save space I figured I could use NTFS disk compression to compress each client. Instead of this saving me disk space, it actually takes up more space — in some cases several gigabytes! So why is it called compression? And is there a way to know in advance if something is worth compressing?

Jordan Hughes

Here's the rhyme I use to help me remember what to do: "Should I compress? I need to know. Oh, that's easy, the answer's 'no.'"

In your specific case, your virtual machines are probably getting bigger because NTFS maintains a lot of metadata for files that aren't

There is a time and a place for disk compression, but the time is always never.

"The best way to find if your slowdowns are caused by a program is by a good old fashioned 'process of elimination.'"

compressed, and also caches uncompressed copies of the files. These will get released after you reboot but modifying a file will create a new uncompressed temporary file. Disk compression is optimised for large data files, not the hundreds of relatively small ones that make up an OS.

But who cares? None of this matters because there is a much better way to free up some disk space: get a bigger disk! A 2TB disk only costs about \$100, or you could just get another 1TB drive for \$70 and put the VMware clients on that.

Luis Villazon

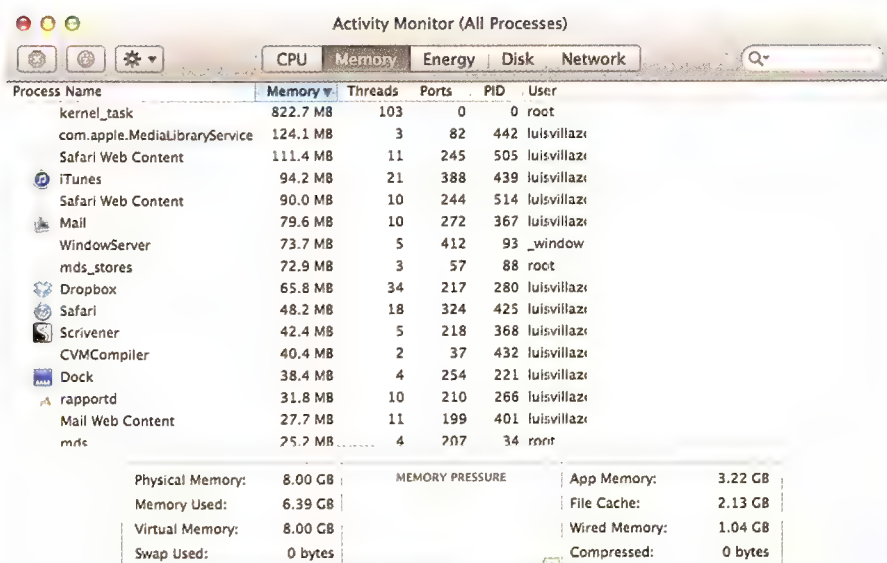
MAC

DOES GRAPHICS RAM RUN OUT?

I have a 15-inch MacBook Pro that slows almost to a standstill when I have several apps open. I think that it may be caused by a low memory condition of some sort. Activity Monitor shows that RAM use and disk use are quite low, so that seems to suggest that it's the graphics memory. Is there any easy way to check how much graphics memory each app is using?

Ashley Faith

The graphics card uses its RAM as a buffer to hold each frame before sending it to the monitor, and as 'scratch' memory for 3D games



You won't see graphics memory listed in Activity Monitor. That's because it's not something you normally need to worry about.

calculations, but it doesn't get full in the same way that system memory does. The best way to find if your slowdowns are caused by a program is by a good old fashioned 'process of elimination'. When your MacBook next slows down, make a note of which applications and documents you have open and shut them down one at a time to see if it makes any difference. It could also be that you have a failing hard disk and apps are waiting for a file to be read from or written to. This won't show up in Activity Monitor because, as far as the OS is concerned, disk activity pauses while it waits for the hard disk to respond.

Luis Villazon

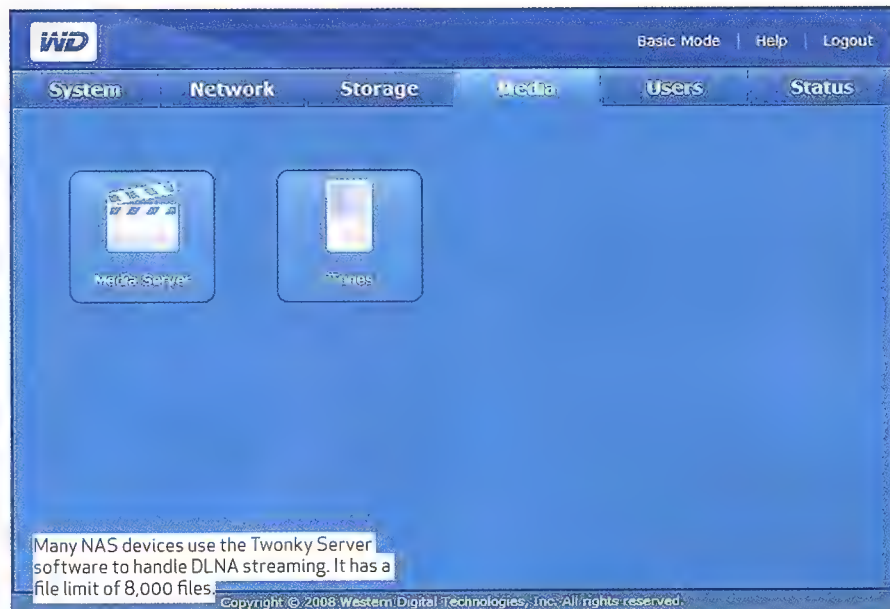
NETWORKING

FILES THAT HIDE THEMSELVES

I have a large collection of files across a 3TB NAS. However, I seem to have hit a file limit and can only see all the files on the NAS in Windows Explorer. Using DLNA on my TV, phone and tablet, I definitely hit a limit on what I can see: as I delete some files, others become visible to take up the slack, so to speak. I am guessing my router is capping this, but I can find very little information about DLNA limits with different routers.

John Wright

DLNA, is a set of standards that provides a way for different devices to share audio and video over a network. It uses UPnP for file handling and there's nothing in UPnP or DLNA that specifies a limit to the number or size of the files



it can handle. But there's nothing in either standard that says a particular media server can't impose a limit. In particular, the Twonky server, used by lots of Linksys and Cisco hardware, and doing the heavy lifting for many mobile apps, has a limit of 8,000 files. On a 3TB drive, that's an average of 0.375GB per file. You probably won't run out if you use your NAS for video, but you almost certainly will if you use it for music or photos. The only work-around I can think of is to partition your NAS into volumes of less than 8,000 files.

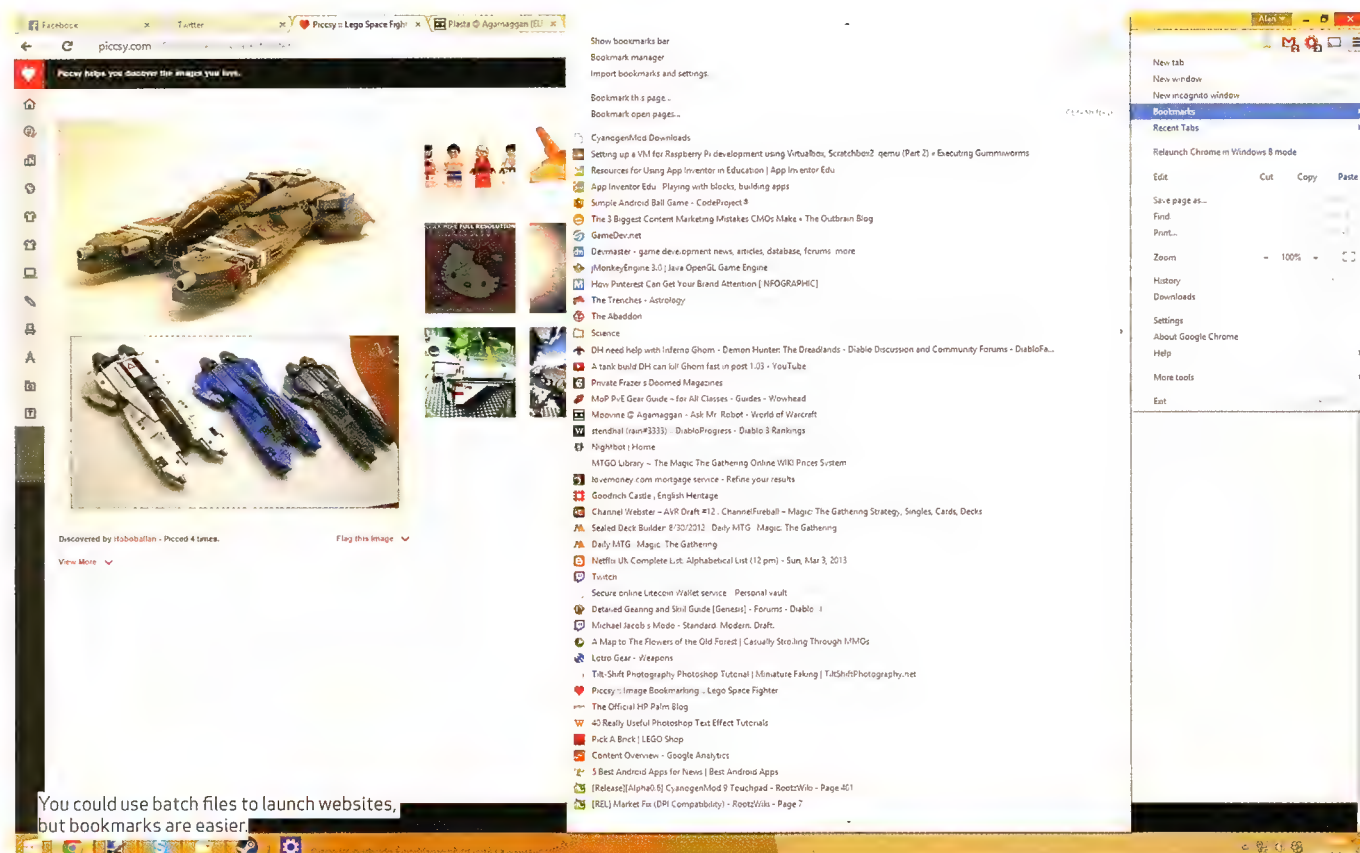
Luis Villazon

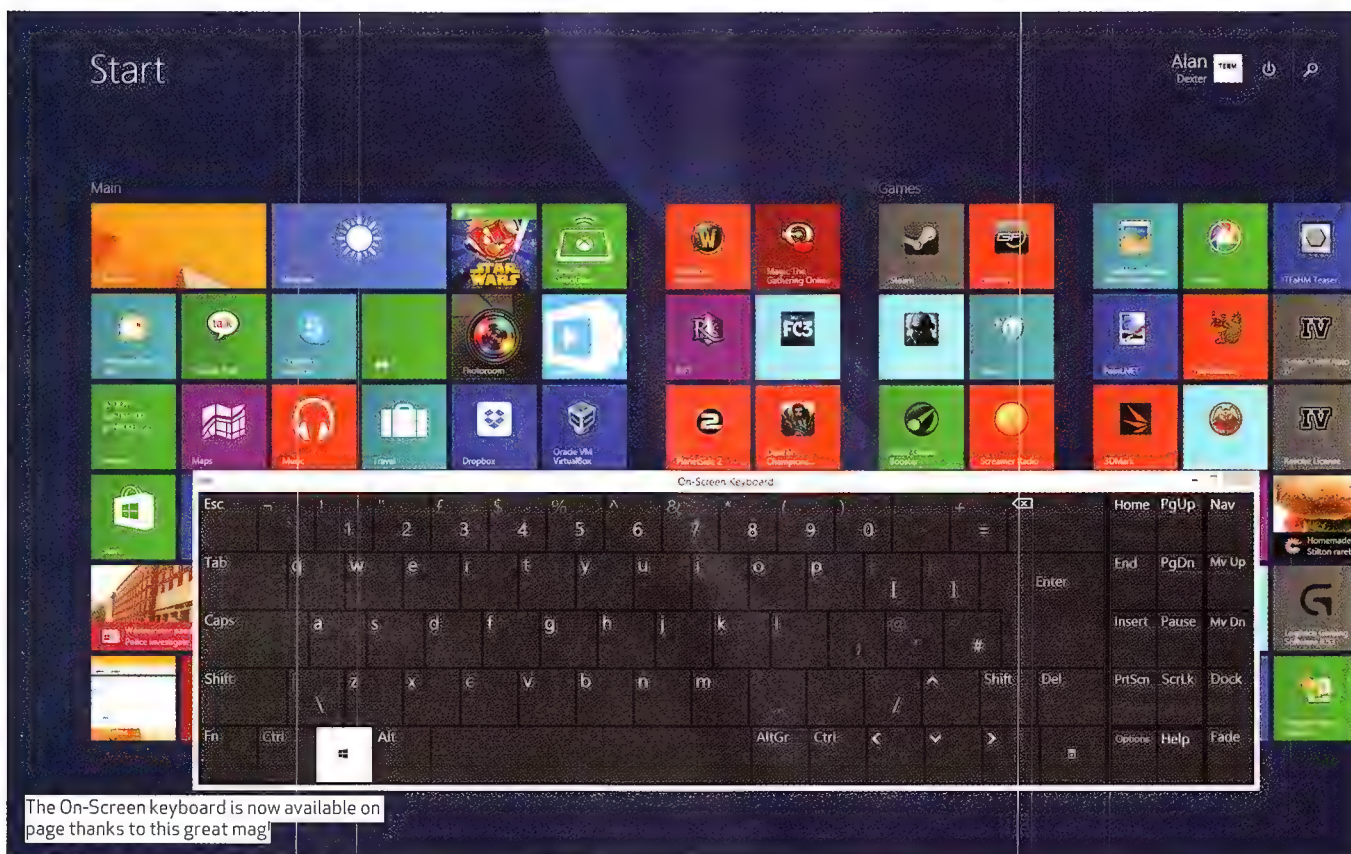
WINDOWS

BATCH TO THE FUTURE

I have recently discovered Windows batch files and have found they are a great way to bend Windows 8 to my will. I am busy assembling a library of shortcuts to all the things I need most often. One thing currently hindering me, though, is web pages. Is there a way to launch a web address directly from the command line? Or failing that, is there a third-party utility that will run them, so I can launch that?

Eric Campion





Yes, it's called a browser. Use the 'start' command in a batch file like this:

```
start http://www.microsoft.com
```

The Windows command interpreter will automatically open your default browser to display the page you specify. This will break if the page's address contains special characters like '?' and '&', unless you use quotes like this:

```
start "" "http://support.microsoft.com/search?query=test"
```

You need the three quotes at the beginning (with a space between the second and third) because the quote marks themselves are a special character, so you need quote marks for your quote marks. (I hear that in Soviet Russia, Marx quotes you.)

I've humoured you this far, partly to show you that I did know the answer, and partly so I could do that Marx joke. But really, this whole batch file kick you're on is madness. Batch files are what we used back in the early 90s, when all we had was batch files and simple flint tools. The only reason they still work in the Windows command prompt is probably because it would be more effort to remove them at this point.

If you want shortcuts to things you do often, Windows has a feature called (drum roll) shortcuts that puts them on the desktop. Or the Start screen. Or the Start bar. If you want to jump straight to a web page, just right-click the desktop, choose 'New > Shortcut' and type the

page's address in the box. Done.

And even this is still a kind of redundant thing to do, because shortcuts to web pages you visit a lot are called bookmarks and you can create them right there in your browser, where you actually need them to be.

Luis Villazon

WINDOWS

THE KEYBOARD THAT WON'T DIE
I have a custom-built desktop PC from Cyberpower, running Windows 8.1. I'm very pleased with it, except that I'm plagued by the on-screen keyboard and the magnifying glass. I think I may have turned them on once, just to see, but I don't want them now. I have searched online for the correct procedure to turn them off and it does indeed work — until I restart the PC. Then it comes back again. Is this setting not saving somehow?

Simon Cordrey

The on-screen keyboard and the magnifier are part of the Ease of Access utilities, and Windows treats these slightly differently from other Control Panel settings. If you need any of these settings to use Windows effectively, the chances are you will also need them to negotiate the Windows login screen, so they need to start before you've typed your password in. This is a potential security loophole, so they need to be sandboxed off in their own little domain.

To change it, you need to open the Windows 7-style Control Panel and then

click 'Ease of Access'. If you are in Category view, you will also need to click 'Ease of Access Center'. Now click 'Change sign-in settings' on the left. You'll see all the assistive technology utilities listed there, each with a checkbox to run it at the login screen, and another checkbox to run it after you have logged in. One or both of these boxes will be ticked for the On-Screen Keyboard and the Magnifier. All you need to do is clear both and click 'OK'.

And this right here is my biggest beef with Windows 8. The Control Panel options are completely undiscoverable. If you know they are there already, you can usually stumble your way onto them eventually. But if you don't know that a setting exists, there is no way to learn about it just by using Windows. This is really, really bad interface design.

I have no problem with the more advanced options being hidden away behind a button labelled 'Advanced'.

I have a huge problem with them just being hidden altogether. Control Panel is flat-out broken in Windows at the moment and if Windows 10 'addresses' this problem by adding yet another layer of interface between me and the same old applets, I will not be responsible for my actions.

Luis Villazon

Understanding Windows 10 privacy

Move over Apple and Google, now Windows desktops are gathering big data. Nathan Taylor explores how to stop it.

By now many of you will have taken your free upgrade to Windows 10. And if you were paying attention during the installation process, and didn't just click through with the default settings, you might have noticed that Microsoft would very much like to gather a lot of data about your activities. You know, to help you out with searches and autocorrect and stuff.

To be fair, it's pretty much the same thing that Apple and Google do, but now it's your desktop PC that wants to gather data on your location and your searches. With that in mind, let's take a look at the key settings in Windows 10 that you might want to adjust to ensure your privacy.

THE PRIVACY SETTINGS

From the Start menu click on Settings, then click on Privacy in the settings Window. This is where most of our adjustments will be made.

In the General tab, we'd recommend turning off all the settings except for SmartScreen Filter. SmartScreen Filter is part of Microsoft's automatic anti-phishing technology. It prevents your browser and certain apps from accessing known malicious web sites.

The other settings you probably want to turn off, however. The advertising ID especially, and the location services probably as well. The one for sending Microsoft data about your typing is mostly benign, but you can turn it off just to be sure.

Head to the Location tab. Like a mobile that allows GPS access for apps, Windows can allow location and location history to be accessible to apps. Although there are some cool apps (like local restaurant searches) that might use this, it's best to turn it off if you're worried about being tracked.

That said, if you want to leave it on you can: when an app first tries to use Windows Location, you'll be asked if you want to give that specific app permission. If you check back on this tab, you can see the list of apps you've given permission to, and disable them at any time. You can also manually clear your location history, so an app

can't track your movement history.

A similar principal applies to the camera and microphone settings. You can turn off all access or enable it and then choose which apps can and cannot access your camera.

With Location, Camera and Microphone settings, a very important caveat applies: these rules you specify here only apply to new apps developed for the new application platform ("runtime") introduced in Windows 8. "Classic" apps that were developed on the older platforms can still access your microphone and camera whether or not you give them permission. Although they can't access Windows Location Services, they may have their own location services with which they might track you.

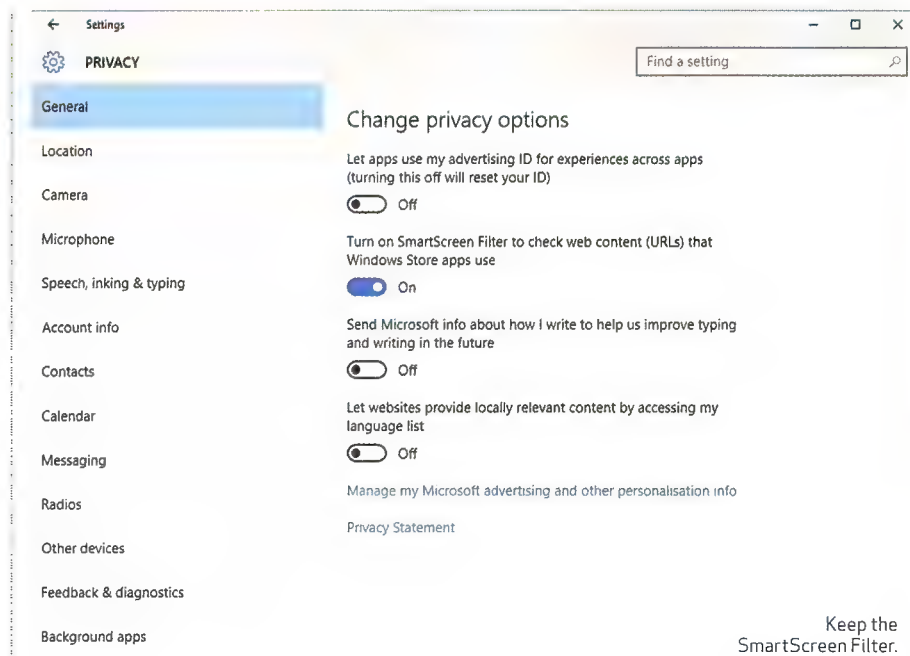
And now that Classic apps are available for download from the Windows Store, it may be hard for you to tell which is which (in Windows 8, only apps that used the new runtime were allowed). Given that, it's important to know that these settings are not a security blanket, and rogue apps can still jack your microphone, GPS and camera.

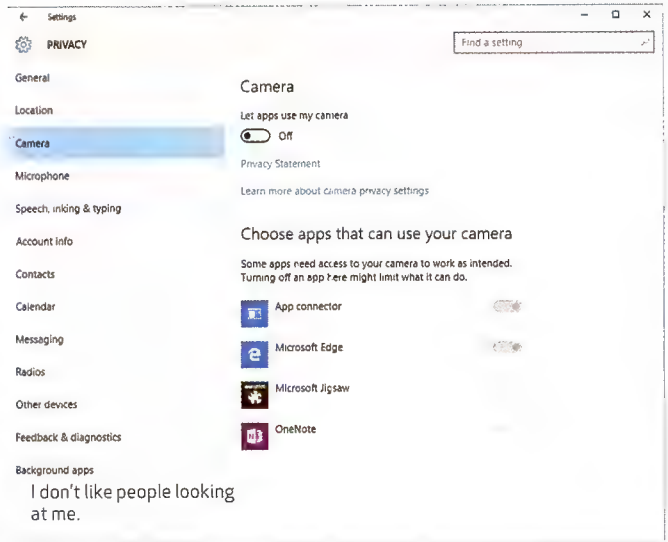
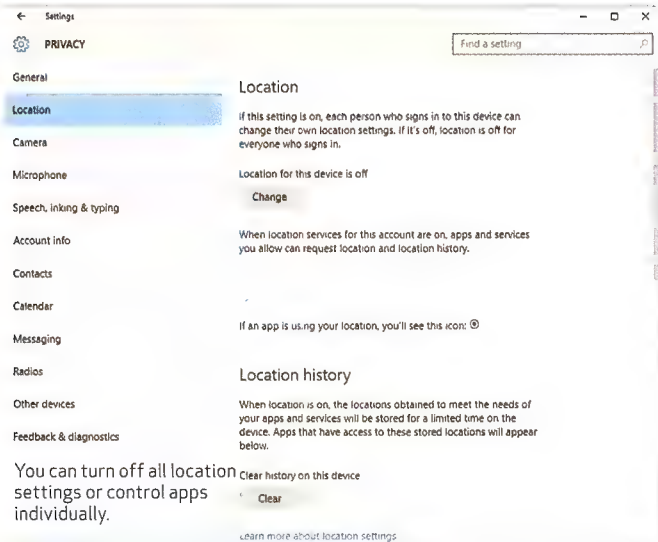
If you head down to Account info,

you have the option to turn off the ability of third party apps to access your account info. If you want to remain as anonymous as possible, you can turn it off — although as with the other settings, Windows will query you on an app-by-app basis if you want to allow it, so it's not that dangerous to leave it on. Ditto for Contacts, Calendar and Messaging.

Click on Feedback and Diagnostics. Here are some settings we do want to change — although it's unfortunate that Windows doesn't let us turn them off completely. You can turn off Feedback — although that's more annoying than dangerous.

The Diagnostic and usage data is more troubling, since you can't turn it off completely on the Home version of Windows. When your system or app crashes, it will send a report back to Microsoft. On the Basic setting, it only sends basic system info (the specs of your system essentially). On Enhanced, it sends your app history. On Full it will grab system files and memory snapshots and send them to Microsoft. We recommend using basic settings.





SHOULD I USE THE MICROSOFT LOGIN OR LOCAL LOGIN?

During the setup process, you'll be given the option to use your Microsoft account or a local login to login to this PC. You can change or access these settings as well by going to 'Settings > Accounts' and looking up your account.

Which you should use really depends on how much data you want to send back to Microsoft. It's up to you. If you use a Microsoft Account to log-in, you'll automatically log into OneDrive and a number of Microsoft services like Xbox and its games services. But you'll also have every Bing and Cortana (when we actually get Cortana) search attached to your record, so to speak, and you'll get targeted ads in Microsoft apps and generally be one with the Microsoft ecosystem.

If you choose a local login, it works much like Windows has always done. Your PC login password is only stored locally, and you have to login individually to apps. Your Microsoft Account can still be attached to your local login. Note that some apps can actually revert your login settings to

the Microsoft Account login if you let them – which is crazy and something you have to keep an eye out for.

WIFI SENSE

Perhaps no feature in Windows 10 has been more controversial than WiFi Sense. The goal of WiFi Sense is kind of admirable – it's there to spare you those awkward moments when a friend or family member comes over and needs your Wi-Fi password, and you have no idea what it is so you have to go digging for the scrap of paper you wrote it on years ago or work out how to unmask the password on your mobile.

Instead of that, WiFi Sense will automatically hand over your Wi-Fi passwords to people on your Skype contact list, your Outlook.com contact list and Facebook friends list. They won't actually be able to see the password, but when they bring their Windows 10 computer over, their computer will ask your computer what the password is and if WiFi Sense is enabled, your computer will tell it.

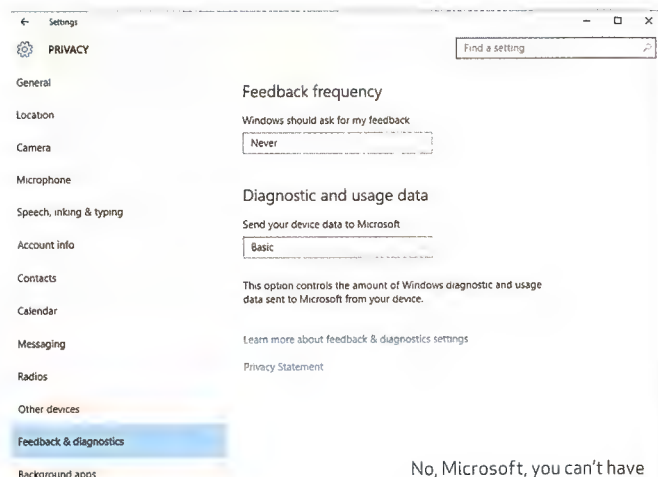
Obviously, that has some troubling

security implications. The potential for it be spoofed or social engineering being used to trick you into friending the wrong person on Facebook is troubling a lot of users. People don't treat their Facebook friends and Skype contacts list as a circle of trust, and they may be worried that, say, a neighbour who they've friended is jacking their internet connection.

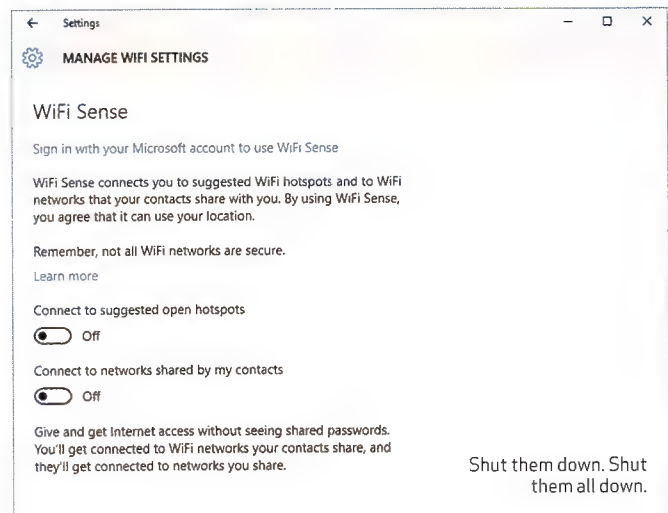
WiFi Sense is enabled by default for Skype and Outlook.com (technically Facebook as well, but it won't actually be able to do anything with the latter until you give it your Facebook login).

If you want to turn it off, you have to go to Settings->Network & Internet. In the WiFi tab (the top one), find the text link to Manage WiFi settings.

For maximum security here, you probably want to turn everything on this page off. Don't connect automatically to open hotspots; don't connect to networks shared by others (turning that off also turns off your own sharing). It's the only way to be sure. ■



No, Microsoft, you can't have a copy of my system files.



Shut them down. Shut them all down.

Recover deleted iCloud documents

If you accidentally delete a document that exists only on iCloud, you can't just pull it out of the Trash — but you can get it back. Matthew JC. Powell shows you how.

Mac users have long had a relaxed, laissez-faire attitude to deleting things. If you throw something away, then realise you ought not to have done that, you can grab it from the Trash. Easy. Of course it gets much harder if you've emptied the Trash, but before you do that you get all sorts of scary messages to make sure you don't do it accidentally.

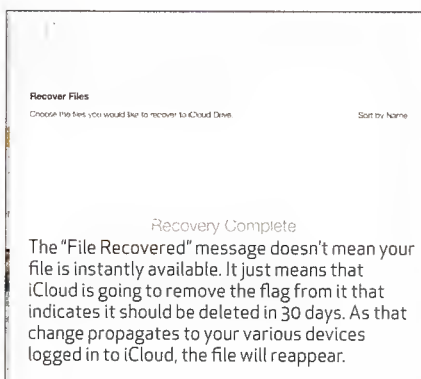
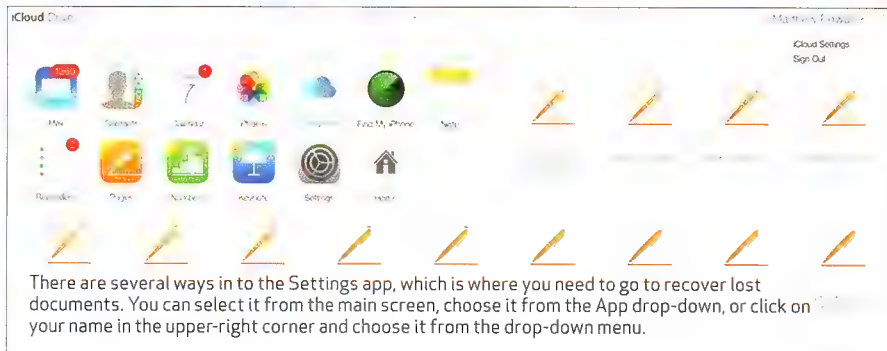
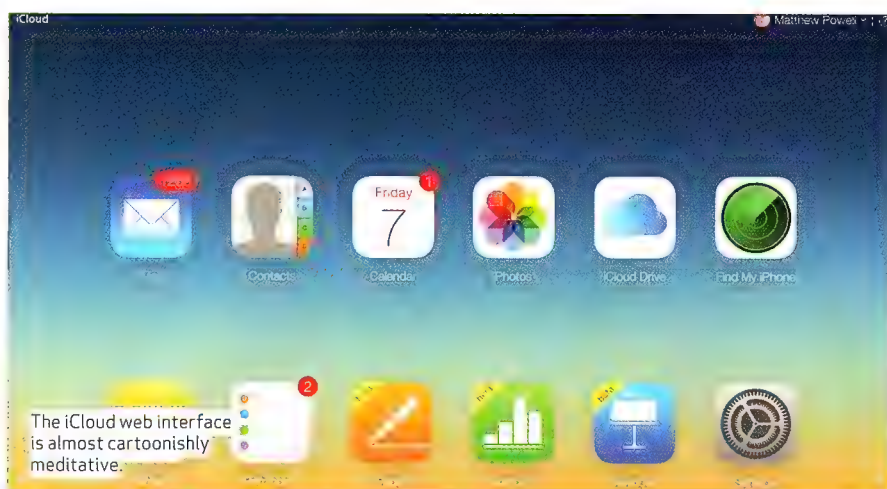
That sense of security ended, however, with the introduction of iCloud and applications like Pages and Numbers that save their documents in iCloud. If you delete a document from Pages, for example, it's gone — just ... gone. Like dust in the wind, never to be seen again. Sort of.

There is actually a way to get accidentally deleted iCloud documents back, but for whatever reason Apple does not make it obvious. And it only works if you're using iCloud Drive, which means you need Yosemite on your Mac and iOS8 on your iOS devices. (There remains no way to recover accidentally deleted iCloud files using your iOS device — even the iCloud Drive app in the iOS 9 Public Beta doesn't appear to address the issue, though this is a beta so the problem may be addressed by the time it ships.)

First, you need to fire up your web browser. The only way to recover iCloud documents is via **iCloud.com** on the web (which, bizarrely, you cannot do on an iOS device — why, Apple, why?).

Go to **iCloud.com** and enter your iCloud username and password. You'll be presented with a lovely gradient to calm your nerves and help you not panic about recovering that lost file. You'll also see a series of icons representing the various applications available to you using iCloud.

You may think that your next step is to click on iCloud Drive and then click on the Trash icon to see what files you've deleted and recover them. This would be analogous to the Finder interface you know and love so well. But you would be wrong, because that's not how this works at all. The Trash icon in iCloud Drive is just for deleting things.



No, what you want to do is click on Settings. For some reason. There you will see how much storage you've used, which devices are logged in to your account, and which Apple IDs are connected to Family Sharing (if you have set that up).

You'll also see a range of options for

managing your Apple ID, and changing the language, time zone and geographic region associated with your iCloud account. And right at the end you'll see an option called "Advanced" and, under it, "Data & Security". Click on that.

What's that, you say? All I want to do is recover a file I accidentally deleted. Why do I have to go into the Advanced Data & Security settings like some sort of geek? Because Apple made it that way. That's why.

Click on Data & Security, and you're presented with three tabs. The first one is Recover Documents, and should be selected by default. In that tab, you'll see all the files that have been deleted in applications that use iCloud Drive but are still available to be recovered. You have about 30 days from when you accidentally delete something to when it really is gone for good — that should



"You have about 30 days from when you accidentally delete something."

By way of contrast: Dropbox

Apple is, admittedly, fairly new to the whole cloud-based file-syncing game, so it can perhaps be forgiven a few eccentricities and stumbles in its early implementation. One company that has been doing this a whole lot longer is Dropbox — a popular choice for Mac and Windows users alike.

In Dropbox, if you accidentally delete a file, you also have the same 30-day grace period that Apple provides to recover the file before it's gone for good (and you can extend that time by using one of several options such as Dropbox Pro — though it's unclear why you would need more than 30 days).

The difference is in how easy it is to do in Dropbox.

As with iCloud Drive, you have to log in to Dropbox on the web. Unlike iCloud Drive, Dropbox allows you to do this on an iOS device. Once you're signed in, you see your various files and folders laid out before you, as you would expect.

You also see a row of icons along the top of the screen. These are, from left to right: Upload, New Folder, Share a Folder, and Show Deleted files.

That's right, clicking on the Trash icon in Dropbox doesn't just delete any file you happen to have selected, the way it does in iCloud Drive.

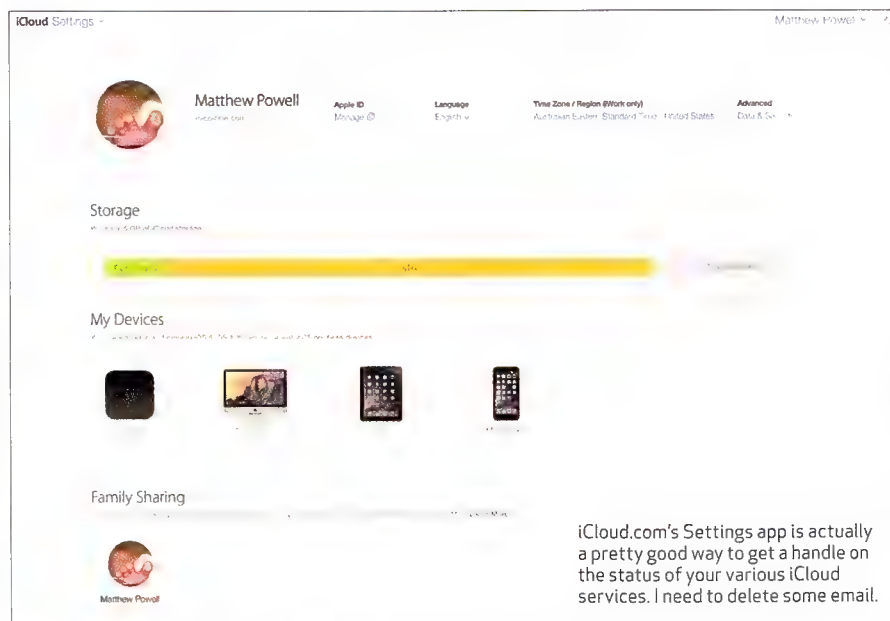
Presuming you know which of your folders the accidentally deleted file was in, you simply navigate to that folder, click on Show Deleted Files, and anything you've deleted from that folder in the last 30 days appears, with a tag saying "deleted".

Click on the file, and you'll be taken to another page, where you then click on "Restore" and the file is re-added to the folder. If it's a file you've modified a few times, you'll even be given the choice of what version to restore.

Apple could learn a thing or two.

In the OS X Finder, clicking on the Trash shows you files you've deleted. So too in Dropbox's web interface. Why not in iCloud's?

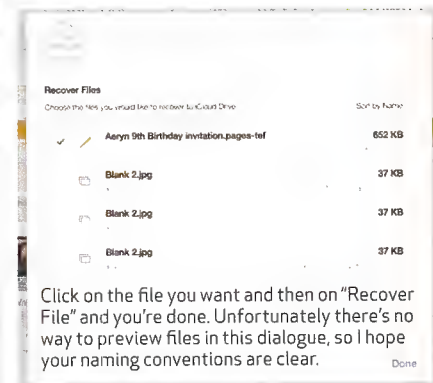
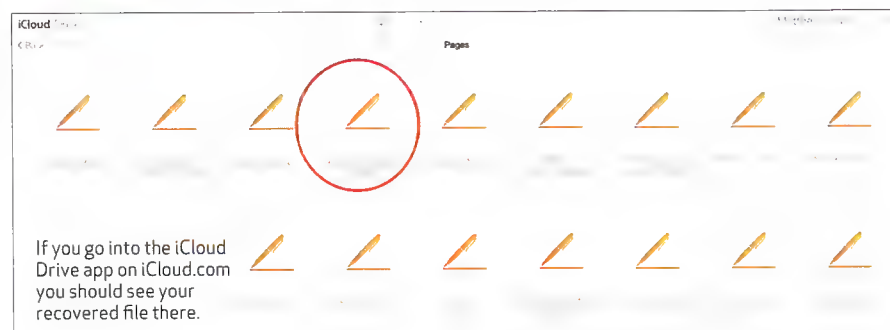
show deleted files



be enough time. If you delete something and only realise two months later that you needed it, you didn't really need it.

As an aside, it seems odd that Apple has built in that 30-day grace period to recover files, given how obscure and counter-intuitive the process for making use of it is.

Tick the box next to the file you want to recover, and the option to "Recover File" appears in the lower-right corner of the window. Click on that, and after a bit of buzzing and whirring the file will disappear from the list and you'll get a message saying that it has been recovered. Note that it can still take a few minutes to show up on iCloud Drive on all your devices, which have to sync first. ■



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Customise iOS Mail gestures

Change the gestures used by iOS Mail to help organise emails in a hurry.

The version of Mail in iOS 8 is a big improvement, and includes a number of features that make it easier to manage the daily barrage of emails. One of the most useful of the new features is the ability to use gestures – a simple finger swipe either left or right across an email in the list for options to quickly delete it, mark it as read or unread, or to perform a number of other tasks without even having to open or read the message.

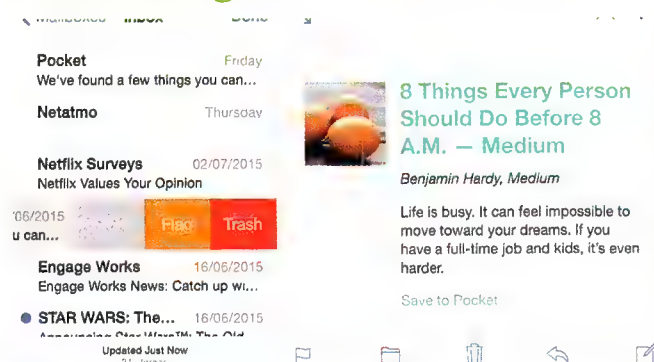
Those two basic gestures work well for triaging new messages, and you

have the ability to customise the actions they perform. (It's no surprise that Microsoft's recently released iOS version of Outlook includes similar gestures.) Your options are fairly limited, but you can do things like switch around the actions (which is handy if you're left-handed), or archive emails rather than simply delete them.

These customisation options are rather limited, but if you dig a little deeper into Mail's settings you can make changes that will help you to organise your emails in the way that suits you best.

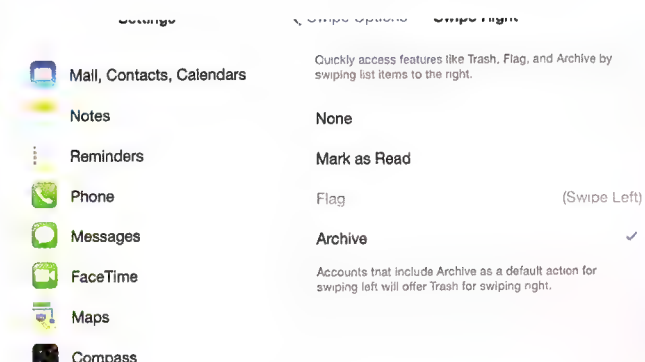
How to:

Customise gestures in iOS Mail.



1 LEFT AND RIGHT SWIPES

You can swipe left to right across a message to mark it as read or unread. Swiping from right to left works slightly differently. A long swipe to the left immediately deletes the email, but by swiping a little more slowly you'll see additional options, such as the ability to flag the email for reading later.



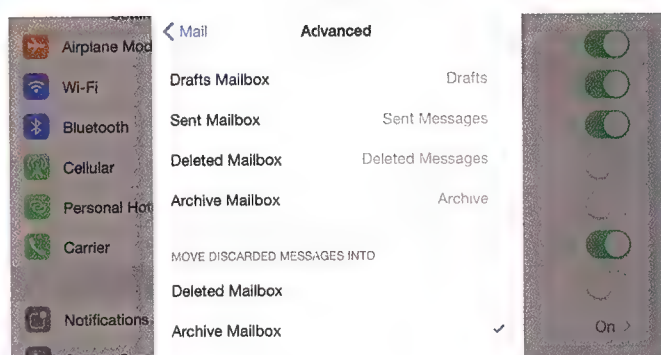
3 CUSTOMISING GESTURES

Your options are fairly limited. If you tap on Swipe Right, you can change it to either flag the email or file it in the Archive mailbox. If you're left-handed you might want to change the Swipe Left gesture to 'Mark as Read' so that the default actions are now reversed. But we're not finished yet.



2 SWIPE AWAY

You can change the way the gestures work in 'Settings > Mail, Contacts, Calendars > Swipe Options'. The diagrams here show the currently assigned actions. Only the actions in the positions shown in blue are changeable. They are set to 'Flag' and 'Mark as Read' by default.



MAIL BEHAVIOURS

In 'Settings > Mail, Contacts, Calendars', tap your iCloud account at the top, then Mail under the Advanced heading. Scroll down and tap Advanced to control which mailboxes are used. You could specify that discarding an email (a left swipe) puts it in the Archive mailbox rather than Deleted.

Working with ranges in Excel macros

Helen Bradley shows you how manage user selections in macros.

It's better form to get a user selection at runtime than it is to abort a macro just to tell the user they should have made a selection first. This month we'll show you how to get a range from a user and some ways to work out just what they selected.

SET UP THE MACRO

Our macro runs from a user form and uses the RefEdit control to allow a user to select one or multiple worksheet ranges. Once they have made their selection, the macro analyses and reports on what was selected. You can use the code from this macro in your own macros when managing user selections.

To create this macro, open the Visual Basic editor from the Developer tab and choose 'Insert > UserForm' and then add a Label, RefEdit, TextBox and two CommandButtons. To add the RefEdit control to your Toolbox right click any command in it, choose Additional Controls and select RefEdit.Ctrl in the list and click OK.

Set the Label caption to read "Select one or more ranges and click Continue", enlarge the TextBox and set its MultiLine property to True and Visible to False. Set CommandButton1 Caption to Continue, and CommandButton2 Caption to Quit and Cancel to True. Set the UserForm Caption to "Analysing User selections".

ADD THE CODE

Double click CommandButton1 and add this code between its Sub and End Sub statements:

```
Dim userRange, rangeDetails As String
userRange = RefEdit1.Value
On Error Resume Next
If userRange <> "" Then
    Set selRange = Range(userRange)
    Application.Goto selRange
    End If
    RefEdit1.Visible = False
    TextBox1.Visible = True
    rangeDetails = "You didn't select any cells"
    Select Case selRange.Areas.Count
        Case 1
            rangeDetails = "You selected this one range: " & Selection.Areas(1).Address(0, 0)
            If selRange.Cells.Count = 1 Then
                rangeDetails = rangeDetails + vbNewLine + "which comprises only one cell"
            End If
        Case Else
            rangeDetails = "You selected " & Str(selRange.Areas.Count) & " ranges"
            For Each i In selRange.Areas
                rangeDetails =
```

```
rangeDetails + vbNewLine + i.Address(0, 0)
            Next i
        End Select
        TextBox1.Value = rangeDetails
        selRange.Style = "20% - Accent2"
        CommandButton1.Visible = False
```

Double click CommandButton2 and add this code between its Sub and End Sub statements:

```
On Error Resume Next
selRange.Style = "Normal"
Unload Me
```

Add this code to the General Declarations area:

```
Public selRange As Range
```

Choose 'Insert > Module' and type this code:

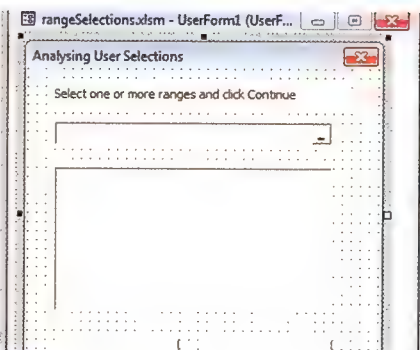
```
Sub AnalyseSelection()
    UserForm1.Show
End Sub
```

Save the project as an Excel Macro-Enabled Workbook (*.xlsm) file before running the macro. The macro analyses the detail returned by the RefEdit control to tell you what they selected, if anything, and how many ranges were selected if more than one.



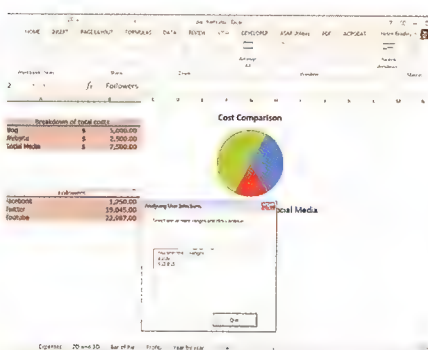
STEP ONE

This is the code for the project, you can grab it from www.apcmag.com/magstuff.



STEP TWO

This is the UserForm at design time. The TextBox control is visible here but will be invisible when the form first appears.



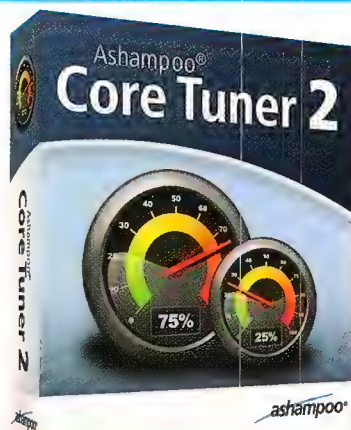
STEP THREE

Run the macro and select one or more ranges by holding the Ctrl key as you do this. Click Continue to learn more about the selected areas.

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BEFORE INSTALLING

- Check the disc using a virus scanner complete with the latest antivirus data updates. The disc was checked before burning, but new viruses are being discovered all the time.
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- If you have any questions regarding the use of the APC disc, click the 'Help' button at the top of the screen.

USING THE DISC

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Networking: The core Linux tools

Mihalis Tsoukalos covers the tools and techniques that you will need to know to begin solving your own networking problems.

Linux has a plethora of command-line tools that are related to networking. We'll cover the most important ones that will help you identify and correct network-related problems. But as a general principle, always use the tool that you know best – provided, of course, that it's suitable for the problem you are trying to solve. Usually, the most difficult part in the process is finding out where the problem is exactly and after finding out the root cause, the fix is generally a relatively easy task.

Never forget to check your log files for errors or warnings related to your issue, which is most helpful for application-level and hardware-related problems. If needed, raise the logging level to get more detailed information. When the problem is resolved, don't forget to lower the logging level because log files can easily become too big.

The most useful practice of all is document everything; write down the ports and the TCP/IP settings of all your network devices, even your Linux machines and network printers, and make a diagram of their connections either by hand or with a tool such as Graphviz (www.graphviz.org), and take notes about them. The second most important advice is that if you have the required resources, it's good to have a backup strategy for everything on your network even if that means that you will have more network devices and servers than needed.

Computer networks fail for many reasons, but these can be divided into three main categories: software-related, hardware-related, and a combination of the two. Problems that turn out to be both hardware- and software-related are the hardest to solve.

However, the nastiest problems are the ones that are related to DNS (Domain Name System). A misbehaving DNS server can cause so many unusual and surprising problems that it's a little breathtaking, especially when the problematic DNS server is one that experiences high traffic and also provides DNS information to many other DNS servers. For example, we



recently had a wrongly configured DNS server that managed to fill the entire disk space of a Linux machine just by generating gigabytes of log messages. The second-most difficult group of problems are to be found in routing, because while most activities might look OK, some activities might not work as expected.

TESTING TIMES

Usually the first thing you try is connecting to a remote machine. This helps you ascertain three fundamental things: (a) whether the problem affects every device on the same network,

(b) whether the problem affects a particular device only, and (c) whether the problem is with a remote machine – the problem is not always going to be on your side.

The simplest way of finding out if two network devices can communicate with each other is by using the ping utility. The problem with this, though, is that ping uses ICMP requests and nowadays most routers and firewalls block such requests that are directed to given hosts. Therefore, even if a ping request fails, you cannot tell for sure if the remote device is out of reach or not.

If you find out that there's a

Visualising network data

All systems and network administrators know how important it is to have a high-level view of network traffic, both for security and network monitoring purposes. As network data flow is getting bigger and bigger, it's very difficult to watch all the data all the time. Therefore, you need a way to get a quick overview of your network data. We've generated a plot in R using the following commands:

```
> timeRel <- read.table("~/Desktop/timeRel.tshark", header=TRUE)
```

```
> plot (timeRel$frame.time_relative,
main="Plotting frame.time_relative field",
col='red')
> grid()
```

The graph visualises the frame.time_relative value, which is the time offset from the first packet. This gives you a good indication of your network traffic flow. Statistics can be very helpful when you have to deal with lots of data but this could be the subject of a separate article.

connectivity issue between your LAN and a remote host then traceroute can help you narrow down the problem. The drawback of traceroute is that it also uses ICMP packages; you will see a "*" character in the output which means that the router in the path doesn't return ICMP messages. You can also use telnet to test a TCP connection. The main benefit of using telnet to manually interact with a server is that you can see the raw data of the connection. Unfortunately, telnet can only be used for testing TCP connections.

Should you wish to test an UDP connection, you will have to choose another tool such as netcat (aka nc) or lsof.

The lsof -i UDP command shows all open UDP connections. Similarly, the netcat -vv -u 8.8.8.8 53 tests the connection with the 8.8.8.8 DNS server that uses UDP. The nc -vnzu 127.0.0.1 1-65535 command scans and shows all open UDP ports on your local machine.

Sometimes, you will have to look at the actual network packets (pictured below). Before inspecting network

traffic, you should first capture it. The best command line tools for capturing network traffic are tcpdump and tshark. Both tools allow you to apply filters during traffic capturing, which reduces the amount of the captured data. For example, tcpdump host 192.168.2.3 captures traffic to or from IP address 192.168.2.3 whereas tcpdump port 53 captures DNS traffic only, which is very handy when you want to examine the behaviour of a given service.

DNS-RELATED TOOLS

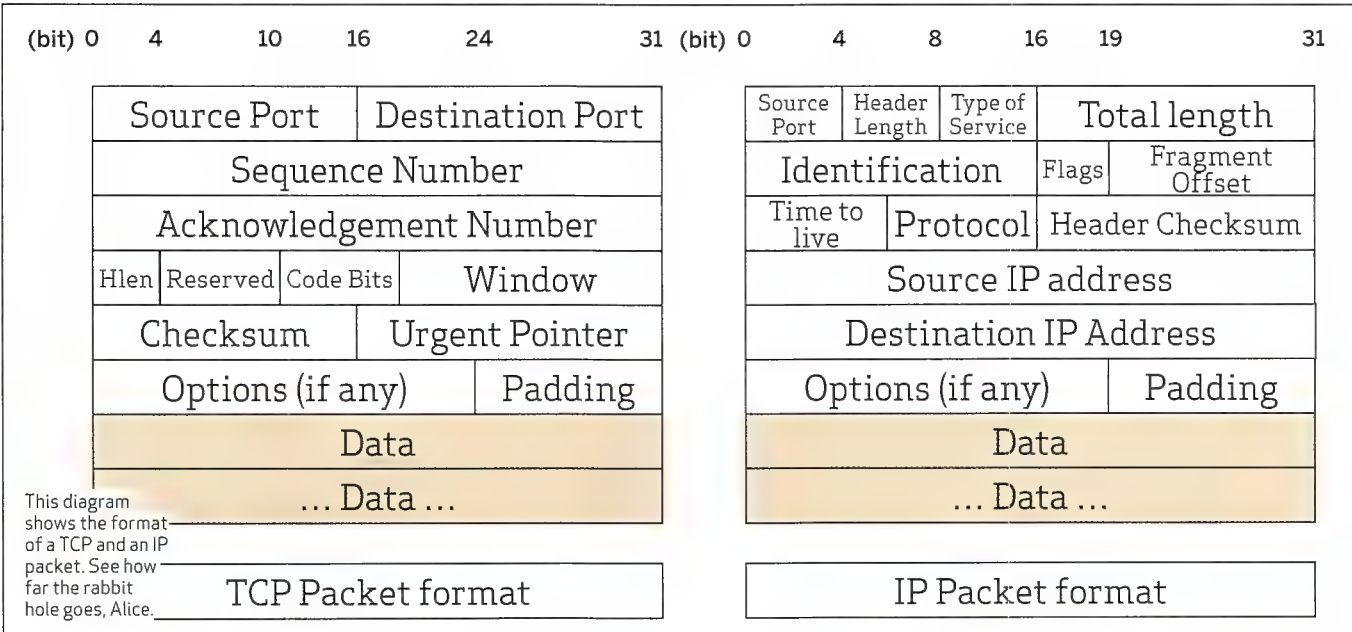
DNS is what converts a human readable string to an IP address. DNS is so important that when it doesn't work appropriately you can't browse the internet or get your email etc. DNS-related problems are usually nasty, tricky and slow to correct, because DNS data is not updated very rapidly. There are three main tools for getting DNS-related information: host, nslookup and dig. All three utilities more or less present the same amount of information when used with the appropriate command line options. Host deals with easy tasks well,

whereas dig is better for more advanced queries and nslookup offers its own interactive shell when used without any command-line arguments. Bear in mind that any answer that comes from the DNS server is considered an authoritative answer as it has the complete zone file information available for the domain.

The following commands present the same information from the DNS servers of the linuxformat.com domain by asking the 8.8.8.8 public DNS server run by Google:

```
# host -t ns linuxformat.com 8.8.8.8
# dig @8.8.8.8 linuxformat.com ns
# nslookup -query=NS linuxformat.com 8.8.8.8
```

To display less information, you can use the +short option. If different DNS servers show different information for the same type of query, you'll know that there's something wrong. If a given Linux machine cannot get an answer to a DNS query, then it's not properly set up.




```

2. mtsouk@mail: ~ (ssh)
mtsouk@mail:~$ dig @8.8.8.8 linuxformat.com ns
; <<> Dig 9.9.5-9-Debian <<> @8.8.8.8 linuxformat.com ns
; (1 server found)
;; global options: +cmd
;; Got answer:
;; -->HEADER<-- opcode: QUERY, status: NOERROR, id: 19266
;; Flags: qr rd ra; QUERY: 1, ANSWER: 2, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, Flags: udp: 512
;; QUESTION SECTION:
;linuxformat.com.                IN      NS

;; ANSWER SECTION:
linuxformat.com.                236     IN      NS      ns0.future.net.uk.
linuxformat.com.                236     IN      NS      ns1.future.net.uk.

;; Query time: 9 msec
;; SERVER: 8.8.8.8#53(8.8.8.8)
;; WHEN: Fri Jul 03 22:32:24 EEST 2015
;; MSG SIZE rcvd: 93

mtsouk@mail:~$ host -t ns linuxformat.com 8.8.8.8
Using domain server:
Name: 8.8.8.8
Address: 8.8.8.8#53
Aliases:

linuxformat.com name server ns0.future.net.uk.
linuxformat.com name server ns1.future.net.uk.
mtsouk@mail:~$ nslookup -query=NS linuxformat.com 8.8.8.8
Server:      8.8.8.8
Address:     8.8.8.8#53

Non-authoritative answer:
linuxformat.com nameserver = ns0.future.net.uk.
linuxformat.com nameserver = ns1.future.net.uk.

```

Using nslookup, host and dig to find out the DNS servers of the linuxformat.com domain. Which utility you use, out of the three, is a matter of personal taste.

```

2. mtsouk@mail: ~/docs/article/working/network.LXI (ssh)
mysql> select count(protocol), protocol FROM netData GROUP BY protocol limit 3;
+-----+-----+
| count(protocol) | protocol |
+-----+-----+
| 11 |          |
| 19 | DATA-TEXT-LINES |
| 3106 | DNS |
+-----+-----+
3 rows in set (0.00 sec)

mysql> select count(*) as TOTAL, SourceIP from netData group by sourceIP order by TOTAL desc limit 10;
+-----+-----+
| TOTAL | SourceIP |
+-----+-----+
| 2098 | 192.168.1.1 |
| 996 | 192.168.1.2 |
| 43 | 192.168.1.3 |
| 38 | 192.168.1.4 |
| 33 | 192.168.1.5 |
| 31 | 192.168.1.6 |
| 27 | 192.168.1.7 |
| 26 | 192.168.1.8 |
| 24 | 192.168.1.9 |
| 23 | 192.168.1.10 |
+-----+-----+
10 rows in set (0.00 sec)

mysql> select COUNT(*), protocol, avg(length) from netData GROUP BY protocol;
+-----+-----+-----+
| COUNT(*) | protocol | avg(length) |
+-----+-----+-----+
| 11 |          | 0.0000 |
| 19 | DATA-TEXT-LINES | 1429.6316 |
| 3106 | DNS | 107.6249 |
| 99 | HTTP | 2022.5657 |
| 16 | MEDIA | 1459.2500 |
| 14 | PNG | 807.2143 |
| 29 | SSH | 114.0000 |
| 1678 | TCP | 1114.6639 |
+-----+-----+-----+

```

A database is a great place to store network data. SQL can make your life easier because it allows you to search your data by executing complex queries.

A Unix command line utility which reads and writes data across network connections is netcat, and it uses the TCP or the UDP protocol. You can do many jobs with it, including creating a web server, a chat server and performing port scanning. Most of netcat's command-line options don't need root privileges to operate; this mainly depends on the port number you want to use when creating a TCP/IP server, because port numbers 0-1024 can only be used by the root user. The default netcat behaviour is similar to a simulated network interaction that uses the `telnet` command, which means two things: the network connection is not encrypted and that the default protocol is TCP.

The command `nc machine_name_or_IP 25` makes netcat interact with a SMTP server, provided that the SMTP server uses the default SMTP port. The command `netcat -l 1234` makes netcat listen to port number 1234 for incoming TCP connections; therefore it acts as a server process. Both operations are useful for testing if two machines can interact with each other. Usually, when they can interact, it means that there isn't a hardware problem and that basic networking is working fine. You should then go on to check your firewall or other processes. This can be easily done by looking at network traffic.

The `lsof` utility is used to list open files and since every network device is a file, it can also be used for getting network-related information, too. You'll need root privileges to run `lsof`, because of the permissions of the network devices.

Using the command `lsof -i4` will

display IPv4 connections while `lsof -i6` will display IPv6 connections only. The `lsof -u www-data | grep -i ESTABL` command displays all established connections owned by the `www-data` user and can be helpful for troubleshooting a misbehaving web server. The `lsof -nP -iTCP -sTCP:LISTEN` command shows which program is listening to a TCP port and the process' owner.

For printing information about the Linux networking subsystem you can use `netstat`. This is a utility that shows information about the network status without needing root privileges. It's a very powerful tool that works on the socket, TCP, UDP, IP and Ethernet level. Its main drawback is that it only works on the local machine while utilities such as `nmap` and `tcpdump` can also display information from other machines. The `netstat -r` command displays the routing information from the local machine; an erroneous routing setup is a common cause of networking problems, especially on machines with more than one network interface.

Sometimes you will want to check not only the current traffic but older network traffic as well. This is tricky because you need to find a way to store older data. The best way is to use a database, because it offers you a language to query your data at no additional cost. The following command will read the `data-tcpdump` file that has traffic captured using `tcpdump` and extract the wanted information in a readable format that can be inserted into a database using a script:

```

$ tshark -r data-tcpdump -T
fields -e frame.number -e
frame.time_relative -e ip.src
-e ip.dst -e frame.protocols
-e frame.len -E header=y -E
quote=n -E occurrence=f
frame.number frame.time_
relative ip.src ip.dst
frame.protocols frame.len
1 0.000000000
82.98.136.22 109.74.193.253
eth:ethertype:ip:udp:dns
108

```

You can see the results from the three queries (pictured above) executed in a MySQL database that

Nmap

Nmap is an open source tool, created by Gordon Fyodor Lyon, that supports port scanning, operating system detection and version detection.

Although regular users can perform various Nmap scans, particular command line options demand root privileges to run. Nmap can help you recognise the type of network device and the services that it runs. You can also tell if you can communicate with the remote device. If you want to ping multiple devices at once, you can always execute a ping scan using Nmap: `nmap -sP 192.168.1.0/24`. The command `nmap -sU aMachine` will also perform a UDP port scan on a machine (called `aMachine`).

About routing

Routing is the process of choosing a path over which to send packets, where dedicated network devices called routers do most of the routing. However, even a computer can act as a router and the more complicated the topology of a network, the more difficult it is to select the optimum path. As you'd expect, the internet is the biggest network of all.

The Routing Table is the place where routes are added; a route is more or less a rule that matches a single network address and defines the next-hop router IP address. If a device on the selected path fails, TCP/IP and the routing protocols will try to find another route to the destination. If an IP address matches several routes, then a set of predefined rules, called the routing algorithm, comes into play to resolve the ambiguity.

Static Routing assumes that the network admin enters all required routing rules into the routing table manually. In Dynamic (or Adaptive) Routing, the necessary routes are discovered by special protocols, called dynamic routing protocols. These protocols exchange special packets, called routing updates, which are added into the routing table. Your Linux distro may use multiple network interfaces (Ethernet, Wi-Fi etc) but only one of them will have a default gateway value. The simplest way to see the routing information of your Linux machine is by executing `netstat -nr`.

The most popular brand that manufactures routers is Cisco. The Cisco's operating system is called Cisco IOS, and you see the routing table of a Cisco 877W ADSL router (right).

```
2. mtsouk@mail-
rMacBook:~$ ssh mtsouk@linode netstat -nr
Kernel IP routing table
Destination Gateway Genmask
0.0.0.0 109.74.193.1 0.0.0.0
109.74.193.0 0.0.0.0 255.255.255.0
rMacBook:~$ ssh mtsouk@linode show ip route
Password:
Codes: C - connected, S - static, R - RIP, M - m
D - EIGRP, EX - EIGRP external, O - OSPF,
NI - OSPF NSSA external type 1, N2 - OSPF
E1 - OSPF external type 1, E2 - OSPF exter
i - IS-IS, su - IS-IS summary, L1 - IS-IS
ia - IS-IS inter area, * - candidate defau
o - ODR, P - periodic downloaded static r

Gateway of last resort is 0.0.0.0 to network 0.0.
2.0.0.0/32 is subnetted, 1 subnets
C 2.86.28.149 is directly connected, Dialer
80.0.0/32 is subnetted, 1 subnets
C 80.106.108.71 is directly connected, Dial
C 192.168.2.0/24 is directly connected, Dot11f
S* 0.0.0.0/0 is directly connected, DialerInMac
```

This is the routing table of a Linux server and a Cisco 877W router. From the output you can see how much more complicated the Cisco device is.

holds network data. The first query shows the connections per protocol. The `limit 3` parameter is used for limiting the output lines. The second query finds the Top-10 Source IPs, and the third query prints the average packet length per protocol as well as the total number of packets.

SQL is a powerful language for asking useful questions that help find historical information about network data. For example a query might reveal that the issue with clients having problems connecting to your servers is down to the high traffic at a particular time. Similarly, you can find out which web server drops connections due to high traffic and upgrade its RAM or use a faster hard disk.

IN THE REAL WORLD

Let's run through two real-world scenarios you might encounter and

work through the problem-solving process. The first one is: a new ADSL router is installed on a LAN in order to connect it to the internet. The LAN is using a hub and a switch. First, a Wi-Fi connection to the router is tested and it works fine allowing devices to access the internet. However, when the hub is connected to the ADSL router using one of the router's ports, no one can access the LAN or the internet any more, not even the existing Wi-Fi connections. We use this process to solve the problem:

- Disconnect all Ethernet cables from the router and connect a laptop to the router using Wi-Fi and DHCP. Use ping and traceroute to test the Wi-Fi. In our case this is successful and so is a request to the router's web interface with wget.
- Connect a machine to one of the switch ports of the router using an

Ethernet cable. Check that the machine is getting its TCP/IP setup using DHCP; in our case the machine is working fine. This proves that the problem is with one of the hub ports.

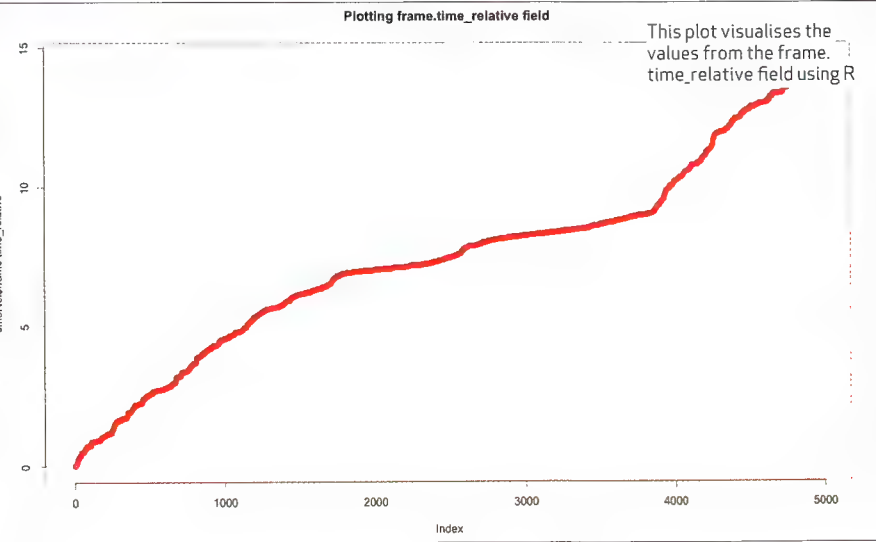
- Disconnect all cables from the problematic hub and connect the 'empty' hub to the router. Then connect Ethernet devices to the hub until a device is connected to the port of the hub that causes the problem – root of the problem.
- The last step is to reboot the router and redo the whole process without using problematic port of the hub. If everything works the problem is fixed!

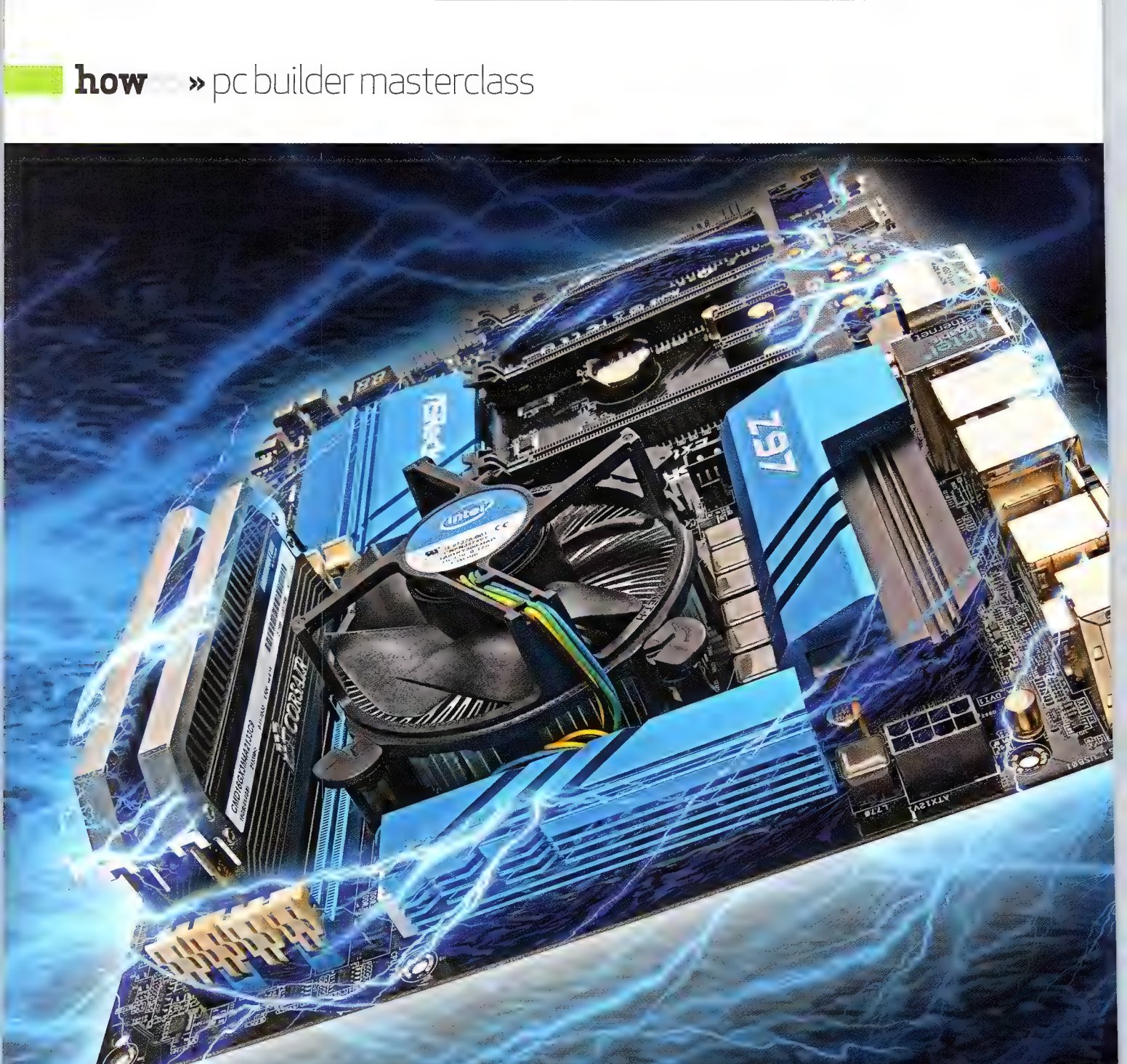
The second scenario is simpler: a Linux machine is set up to get the log messages from a Cisco router and the router is set up to send log messages to the Linux machine, but there's nothing showing up in the log files of the Linux machine.

The Linux box uses the rsyslog service to get the messages. Usually, there's a time delay between when rsyslog gets the data and the data is written to a log file.

Since rsyslog is a UDP service that listens to port 514, we can use `tcpdump 'udp port 514'` to test if there's any network traffic for the service on the Linux machine. Once the traffic is there, it's also written to the appropriate log file, which proves that there's no problem at all.

Wireshark could have been used for this same job but running it on a remote machine is not always possible, so never underestimate the power of command line tools!





PC overclocking masterclass

Zak Storey reveals the hardware, software and know-how you need to get the most from your PC.

Overclocking. It's long been a part of a PC enthusiast's toolkit when it comes to wringing every last ounce of power from our beloved machines. Whether you've opted to run AMD or Intel, overclocking has been a staple food group of the techie's diet for as long as there's been chips in PCs. The basic principle is simple: Add more voltage to the component part, provide it with sufficient cooling, either through water or air (or LN₂ for

the more adventurous among us), and increase the Hz output of the hardware you're trying to improve.

But this doesn't come without risk. While we've come a long way in the world of overclocking, it is still possible to fry your CPU, GPU, RAM or motherboard to the point where it's more charred than your old man's best barbecued sausages. So, the first question you should always be asking yourself is whether it's worth the risk. The answer, generally (and, ahem,

unhelpfully), is sort of.

As proven time and again by Intel's latest and greatest chips, a good quality CPU core often outstrips an increase in gigahertz. On the flip side, however, increasing the performance of a two-year-old core so that it can keep pace with the newer generation can save yourself a pretty penny, and possibly put off that upgrade for another year or more. So read on for step-by-step guides to overclocking your CPU, RAM and GPU.

Overclocking your CPU

Learn to fulfil your processor's potential in 10 simple steps.

Before crossing the start line, there's a few basic principles to get your head around. The first one is heat. Inevitably, the more voltage you add to your components, the more heat that component is going to output. Second, the higher the clockspeed you're trying to achieve, the more voltage you will need to power that attempt. And thirdly, there's only so much voltage your PC part can take before you start to see detrimental effects. These could be a drop in frame rates for GPUs, corrupting processes on the CPU, or even a failure to boot at all. These, essentially, are the basic limits of overclocking.

All chips are born equal, but some are more equal than others. You'll often hear overclockers talk of 'The Silicon

Lottery'. In short, this is to do with the manufacturing process with each and every processor. Small imperfections in the application of the silicon lead to a variance in how well the chips perform, both in stability with an increase in voltage, and how much heat they produce at max load. You might get lucky with yours, or you might not. It can equate from anywhere between 0.2GHz difference to, in some cases, up to 1GHz in overclocking potential.

So, assuming you've got an aftermarket cooler of some description (see "Picking a Cooler"), that you have a processor or component that's capable of overclocking (K/X series for Intel and any AMD chip), and that you understand how to get into your BIOS, here's how to get going.

1 CHECKING CPU STABILITY

To ensure a successful overclock, we'll need to know that the CPU is stable at both idle and max load. To do this, we'll be using a free piece of software called Prime95, from www.mersenne.org/download/. You'll also want to download a program to accurately monitor the temperatures your CPU is outputting. For this we'll use Core Temp, from www.alcpu.com/CoreTemp/, as this works with both AMD and Intel cores. There are alternatives out there – Corsair and NZXT have proprietary software that works with their AIOs, plus most motherboards have viewable

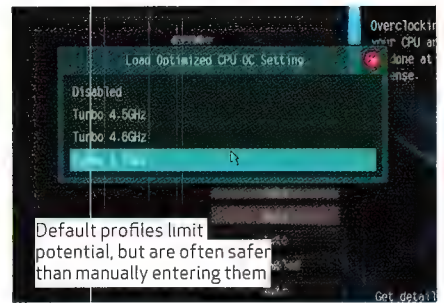
temperature controls that you can use from the desktop. If you don't fancy installing anything on your rig, then Real Temp GT is your guy.

2 CORE TEMP

Once those programs are extracted or installed, load Core Temp to begin monitoring your CPU's temperature. Always look at the lowest core temp to give yourself a good understanding of how hot your CPU is running.

3 STRESS TESTS

Now we'll want to benchmark your CPU, at stock, to see how hot it



runs at 100%. Start Prime95, select 'Just stress testing', and then you'll be given a list of options as to which stress test you'd like to perform. Choose 'Blend Test' and press OK.

4 INTO THE BIOS

After about 5-10 minutes, once your temperatures have stabilised, go into Prime95. Select 'Test' on the top bar and hit 'Stop', then restart your PC and mash that Delete key to get into your BIOS. In this test we're using an ASRock Z97 Extreme 4 motherboard, so the UEFI could be a little different in comparison to some of the other manufacturers you'll find out there, but the base settings will essentially be the same.

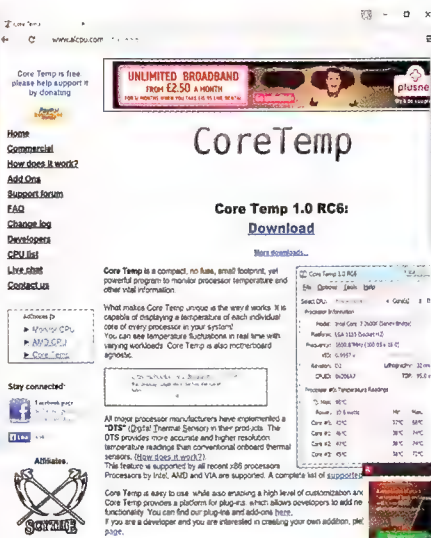
5 AUTO-OVERCLOCK

Once inside your BIOS, find the overclocking tab. In ours it's named 'OC Tweaker'. Once in, you have several options. The easiest way to overclock your CPU is to let the motherboard do the majority of the work. Most manufacturers will include overclock profiles, usually ranging from 4GHz to 4.8GHz, depending on the CPU installed.

Setting the motherboard to run one of these profiles will allow it to attempt to overclock the chip to that frequency without any user input. This can be a quick solution, especially if you're only dialling in a conservative overclock (3.5GHz to 4GHz, for example), but this isn't conducive if you want to push beyond that 4.8GHz barrier, or if you can't reach that frequency through the automated profiles.

6 CHANGING THE MULTIPLIER

More adept users will find manual control a lot more comprehensive in regards to what true overclocking is all about. To keep it simple, you want to be changing the CPU ratio, or multiplier, for all cores to the target number you wish to achieve. That's 35 in this case. The multiplier then works with the cores' BCLK frequency (usually 100) to create that final figure of 3.5GHz. In this tutorial, we're going to attempt to overclock our CPU just to start with from 3.5 to 4GHz, simply by changing the multiplier.





7 TEST AT MAX LOAD

Once you've changed the CPU ratio multiplier to 40, save changes and exit the BIOS. Boot into Windows, open Core Temp to monitor your CPU temp, then open Prime95 and select 'Options', 'Torture Test' and finally 'Blends Test', to see how your chip fairs at max load. If it's stable for at least five minutes, we can begin to up the multiplier to achieve a higher overclock.

8 FINDING THE LIMIT

At this point, you'll want to increase the multiplier by one and repeat the process of stress testing in Windows each time, until you reach the point where you initially either blue screen or your CPU begins to thermally throttle itself. Ideally, you want to blue screen before you reach your thermal limit.

9 INCREASING THE VOLTAGE

To overcome the blue screen issue, we need to start working with the Vcore voltage. Back in the BIOS you want to find CPU Vcore Voltage Mode. Change this to 'Fixed'. At this point you may need to do some research as to

what stock Vcore your CPU takes, and what people are suggesting for overclocking. You'll want to begin increasing the voltage by 0.01 volts each time, until you can successfully boot, stress test and maintain stability at your target frequency. Once you get a little more comfortable overclocking, you'll find yourself increasing voltages by 0.05 or 0.1 at a time. It's more about learning how your CPU responds to different amounts of voltage at this point.

Eventually, you'll reach a point where you cannot reach that next frequency, regardless of how much voltage you throw at it. This is when you want to dial back your overclock by 0.1GHz and drop the Vcore voltage back to the last stable settings for that frequency and maintain it there, as this is your final overclock.

10 BACK TO BENCHMARKING

To ensure a stable overclock, you should now benchmark for as long as you feel is appropriate. This can be anywhere from an hour to a full day, depending on how patient you are.

Picking a cooler

The first thing to consider is what you'll use to cool your components. The stock coolers AMD and Intel provide won't cut it when it comes to dissipating the excess heat that comes from adding more voltage. They're designed to deal with what the processor can output at stock frequencies, and not a lot more.

AIR

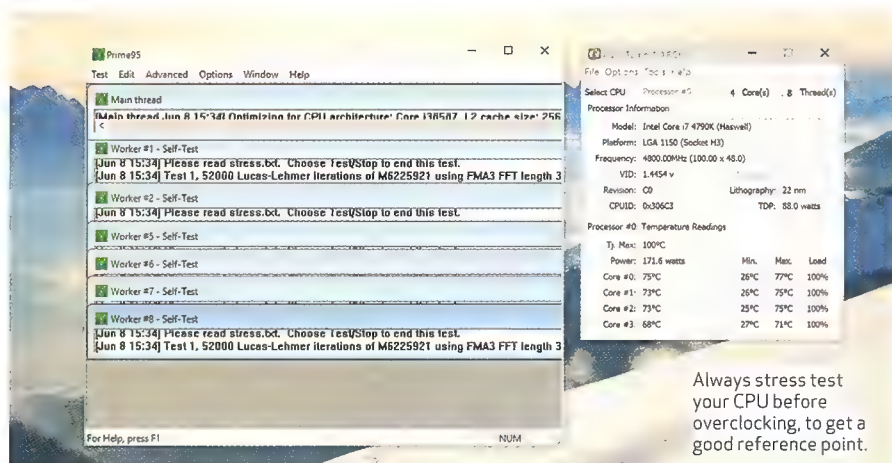
The more traditional, easier solution would be to rely on air cooling for your CPU. There's a huge list of air coolers out there, from a wide variety of brands, but it's vital that you consider the size of the cooler versus the height of your RAM and the size of your case. The last thing you want is to buy a new heatsink for your shiny new i7-4790K, only to discover it won't fit over the top of your Corsair Dominator GTs. The Dark Rock Pro 3 is a particular favourite of ours — it's silent, yet can effectively relieve your CPU of over 250W of TDP, plus it'll keep your bacon cool.

AID WATER COOLING

The second option is an all-in-one water cooling loop. You've probably seen a lot of these kicking about — Corsair's Hydro H100i being the more famous of the bunch. These are a quick and easy solution, and often provide a great deal more cooling than a single air cooler, due to their increased surface area. They're also a lot less finicky to install (providing you have the radiator support), and can clean up your rig quite nicely while allowing you to swap out components with relative ease.

CUSTOM-LOOP COOLING

Finally, the elephant in the room, the fully custom loop. It's the dream, the crème de la crème, and the aspiration of every tech enthusiast starting out on the bumpy road to a successful overclock. It's also something that's become increasingly easy to build in recent years. Although certainly the most effective of the three, due to the ability to expand on your loop by adding more radiators, and cool more components, it can become very rigid, especially if you want to change out a graphics card, for example. It's definitely something that needs to be researched fully before committing to, if only because it can easily add to your costs. And that's with the cheapest components out there. But wow, does it look good when you're done. The Parvum Titanfall rig is a prime example of this.



Always stress test your CPU before overclocking, to get a good reference point.

Overclocking your RAM

Wait! There's more! Overclocking isn't limited to just your processor.

Yes. It's true. Overclocking doesn't just mean tinkering with your CPU. Other avenues exist if you're keen to shove the boat out a little bit more.

RAM speeds over the course of the last few years have almost tripled in frequency, meaning performance can be improved quite dramatically in certain computational programs. It's important to bear in mind, however, that the higher you push your RAM frequency, the more your CPU will suffer. In other words, it might mean an overall lower final overclock for your little powerhouse.

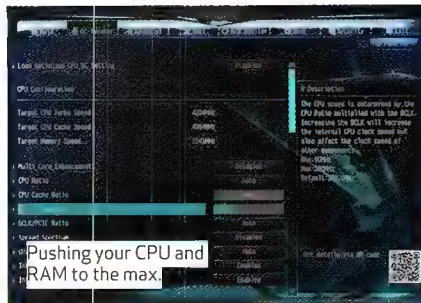
On the other hand, AMD's APU's, despite being a lower-end graphics solution, will benefit hugely from an increase in those same frequencies. So, what does all this come down to?

1 WHAT'S THE FREQUENCY? Identifying the frequency of your RAM on purchase is crucial. We wouldn't go for anything less than 1,600MHz as a minimum if building a rig today. With Skylake and DDR4 around the corner, we'd be tempted to hold off a little and wait for that, as the price of the next generation of memory is still continuing to plummet.

2 THE PROFILE SETUP We're using a pair of Corsair Dominator Platinums, clocked at a stock speed of 2,133MHz. To take advantage of any potential additional clockspeed, you'll need to set up the memory with the correct profile on install. So, either Intel's XMP profiles or AMD's AMP profiles. This is exactly what we'll be using, just to do a slight overclock of the memory.

3 PUPPING THE FREQUENCY Enter your BIOS by again headbutting the Delete key. Make sure you have either your XMP profile or your AMP profile selected, then change the memory frequency to one frequency higher than your memory's stock frequency. In all likelihood, your RAM should be able to manage and maintain that frequency, regardless of what the stock speeds say.

4 ABOVE AND BEYOND If you want to take it further, this time we'll change the BCLK frequency, instead of adjusting a RAM multiplier. You can up this in very small increments. But it also ups your CPU's basic overclock, so if you've already OCed your chip to the absolute max, it's unlikely you'll be able to push the memory or the CPU any further.



CPU BENCHMARKS				
	CORE I5-4670K TURBO TO 3.8GHZ	CORE I5-4670K OC TO 4.5GHZ	CORE I7-4790K TURBO TO 4.4GHZ	CORE I7-4790K OC TO 4.8GHZ
IDLE TEMP (°C)	29	29	27	31
LOAD TEMP (°C)	71	84	62	70
CINEBENCH	566	667	877	943
TOTAL WAR: ROME II (MIN/AVG/MAX FPS)	19/40/59	16/40/53	16/42/58	17/42/57
VSCORE	N/A	1.385	N/A	1.445

TESTS CARRIED OUT ON MAX SETTINGS/SHADER MODEL 4.1/1440P.

GPU BENCHMARKS		
	STOCK-CLOCKED GTX 980	OVER-CLOCKED GTX 980
TOTAL WAR: ROME II MINIMUM FPS	17	17
TOTAL WAR: ROME II AVERAGE FPS	45	54
TOTAL WAR: ROME II MAXIMUM FPS	57	67
3D MARK FIRESTRIKE EXTREME	5,654	6,558

TESTS CARRIED OUT ON MAX SETTINGS/SHADER
MODEL 4.1/1440P.

TEST BENCH SPECIFICATIONS	
CPU	INTEL I5-4670K / INTEL I7-4790K
MOTHERBOARD	ASROCK Z97 EXTREME4
MEMORY	CORSAIR DOMINATOR PLATINUM (2X 4GB) 2,133MHZ
GRAPHICS	NVIDIA GEFORCE GTX 980
SSD	OCZ ARC 100 (240GB)
POWER SUPPLY	BITFENIX FURY 750W

Mobos and PSUs

Once you've got your cooling sorted, you also want to make sure you've got the best possible components that you can budget for in regards to stability. That means two items in particular — the power supply unit (PSU) and the motherboard. They are both imperatively important when it comes to overclocking. Perhaps most obvious is buying a motherboard that supports overclocking. For Intel, that's any motherboard with the Z97 chipset. For AMD users, it's currently any FM2 or AM3+ board.

Concerning power supplies, you want to be looking at a PSU that has at least 20% spare capacity, in terms of wattage, over what your system requires. Preferably, push as much money as you can into it. The higher-end power supplies not only feature better surge protection, but also provide a more consistent flow of electricity between the wall and your PC parts. This should result in longer life and more stability, both when overclocking and through everyday usage.

Overclocking your GPU

Last, but certainly not least, the final hurrah of overclocking.



With DirectX 11, at least, OCing the GPU is the area of most benefit to gamers. But it's also where overclocking has most dramatically changed. That's because, with Nvidia's GPU Boost and AMD's Power Tune, it's no longer possible to simply up the voltage and in turn increase cards' core clock speeds.

It's now often better to ignore the voltage and let the proprietary software do its own thing. This way you can avoid reaching the artificial power limits set by our GPU overlords — cores won't throttle themselves in an attempt to control imaginary temperatures, that may or may not be present, even if they're running on an aftermarket cooler, or water. Sounds ridiculous, right? You're not wrong. Still, we'll show you how far you can go with these cards.



1 GET THE SOFTWARE

Unlike CPU overclocking, we need to download some proprietary software to use within Windows. It's usually most beneficial to download whichever manufacturer's software your card's PCB is based upon. GPU Tweak for ASUS, Afterburner for MSI, and so on. In this case, we're using a reference cooler on our GTX 980, so we're using MSI's Afterburner. It provides frame monitoring for benchmarking, a customisable display and in-game overlays to monitor how the cards perform compared to their stock speeds.

2 ENABLE MONITORING

Once Afterburner is installed, the first thing we want to do is enable in-game overlay, and frame rate monitoring, followed by (for us at least) changing the skin to something a little more workable.

3 TEST STOCK SPEEDS

Next you'll want to get a clear understanding of how your card performs at stock speeds. We're using Total War: Rome II's benchmarking software at max settings at 2,560 x 1,440. We achieved a minimum frame rate of 19, a max of 61, and more importantly an average of 44.7.

4 INCREASE THE POWER LIMIT

We now need to get into the overclocking side of things. Head back to the desktop and open up MSI Afterburner again. The first thing

we're going to increase is the power limit. Move the slider to as high as it will go. This should allow our card to use absolutely every inch of power we can get, beyond Nvidia's recommended stock settings, meaning the card can run all the way up to 91°C, as opposed to the stock 79°C.

5 UP THE CLOCK SPEED

Start by increasing the clockspeed. Research what's most suitable for your card. In our case, a healthy overclock for the core clock should be an extra 225–275MHz offset, so we go for 240MHz.

6 NOW THE MEMORY CLOCK SPEED

Lastly, we're going to increase the memory clockspeed. After research, we can see the community, on average, is aiming for around 450MHz. We'll try that and see how it goes, leaving Nvidia's GPU Boost to calculate exactly how much voltage we need. All that's left to do is press 'Apply' and go back into the benchmark to see how the card performs.

In the Total War: Rome II benchmark, we achieved a minimum frame rate of 17 at overclock, a maximum of 67, and more importantly an average of 53.6, an increase of almost 9fps towards that average. Granted, the delta between the minimum and the average is considerably greater than the stocklocked version, but who can argue with free performance?

Conclusion

Welcome to the world of overclocking, a place where dreams are realised, and where having just enough of those overclocking chops may mean the difference between a world record-breaking benchmark or a session crying into a pile of burnt-out chips and GPUs.

As mentioned at the beginning of this guide, OCing isn't for the faint-hearted. You can do a considerable amount of damage to your CPU and other component parts, so it's not something to be taken lightly. What's more, in some cases, the performance gains are negligible. But, if you're interested in eeking every last ounce of power from your machine, this is definitely the hobby for you.

It's something the vast majority of PC users will shy away from, and it's understandable why — the thought of placing extra strain on any of your components for the sake of a few more points in Cinebench hardly seems worth it at times. But when you're sitting there, in front of a stable 5GHz overclock on an ITX motherboard, with a chip being cooled by a single 120mm radiator outperforming cores half its age, there's almost an odd sense of pride about it all. A bond between man and chip. Yes, we went there. ■



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TECHNOLOGY. TESTED.

Make music with a Pi

Les Pounder serves up a selection of 'phat beats' using nothing more than a Raspberry Pi and Raspbian.

For this project you'll need any Pi model and Raspbian (www.raspberrypi.org/downloads). In previous tutorials we've mostly focused on creating physical projects that can be interacted with, but this time we'll delve into the world of music using Sonic Pi. This is the personal project of Dr. Sam Aaron and the goal of Sonic Pi is to introduce creativity into programming via music and reduce the friction that's encountered by children learning to code, eg the alignment and indentation of code and syntax errors.

Sonic Pi uses the Ruby programming language created in the mid 1990s by Yukihiro "Matz" Matsumoto, which was an easy to learn and syntax-friendly alternative to the languages of that time. Sonic Pi refines the Ruby language to provide a number of easy to use functions that enable learning. In this tutorial we'll learn the basics of

Sonic Pi and then consolidate that knowledge with a piece of music.

Sonic Pi comes preinstalled with Raspbian but if you have an older installation it's possible that your version of Sonic Pi is quite old. It's well worth updating the software installed on your Pi by opening a terminal and typing the following:

```
# sudo apt-get update
# sudo apt-get upgrade
```

If you are prompted to confirm installation, please do so. With Sonic Pi installed you can find the application in the 'Programming' menu. Open the interface and you'll see that the interface is split into three vertically tiled panes. The top pane contains a row of buttons that are used to control the playback of your composition, save the composition to a file and also record the audio to a WAV file. Further buttons are used to reduce the text size

of your code, align and indent code automatically and access the Help/Preferences system. The centre pane contains the area in which code is written, which is split into a series of workspaces enabling you to write multiple compositions or test logic in a spare workspace. To the right of the code area is the Preferences area where configuration changes can be made at the bottom. We also have the help area which contains extensive help documentation and example compositions.

Lets start our musical adventure by playing a note. In the coding pane type `RUBY//play 60`. Now press 'Run' on the top pane. You should hear the note briefly play. What does 60 mean? Well it refers to the MIDI (Musical Instrument Digital Interface) numbering scheme, which is used in professional music production to cover the protocol by which data is sent to and from computers and digital



π)))
Sonic Pi

The Sonic Pi interface has been designed to offer a frictionless approach to composition using code.

Live coding!

Dr. Sam Aaron is a bright and bubbly individual who knows his craft well and loves to show others, so it's no surprise that he's a big advocate for Live Coding, the practice of coding in front of a live audience. Sam is part of the band Meta-ex (<http://meta-ex.com>), along with Jonathan Graham. Together they merge coding with musical instruments to create unique performances, where the audience can see the code transform to match the tone and pace of the music.

At the recent OpenTech event in London, we saw open

data, in the form of natural disaster data, being used to shape the notes used in a rather eclectic piece of music. The piece co-produced by Leah Borrromeo and Jamie Perera used data sonification. However, this wasn't a real-time project, which opens the door for Sonic Pi to be used with open data in a live coding exhibition. Data from a number of sources, such as online news outlets, weather reports and government data feeds can be 'mashed' into a live coding musical composition that can illustrate the subject of the data being used.



At the top of the user interface are a series of buttons to control the playback and recording of your code and to align or resize the code to meet your needs.

instruments, but it also covers the connection made between the devices. The 60 note refers to a C4 note, but we can just use the name of the note instead so `RUBY//play :c4`.

If we wanted to play a series of notes then we could type out something like

```
play :c4
sleep 1
play :g4
sleep 1
play :d4
sleep 1
```

This is a correct but rather long-winded approach. Instead, Sonic Pi enables you to play patterns of notes in the same manner with:

```
play_pattern [ :c4, :g4, :d4 ]
```

Perhaps the notes are a little too slow for you? Well, Sonic Pi has you covered. To speed up the playback of a composition, we can set the Beats Per Minute (BPM) for playing that pattern of notes faster:

```
use_bpm 240
play_pattern [ :c4, :g4, :d4 ]
```

USING SYNTHS

So we can play a series of notes, but right now it's not very exciting so let's introduce another feature of Sonic Pi: synths.

Synths enable a note to be played with many different instruments, similar to electronic keyboards and other digital instruments. So let's alter our code to use a synth:

```
use_synth :dsaw
play :c4
```

Press 'Run' to hear the difference. So now that we can play a note with a synth, let's put it into a loop to repeat

playback. Sonic Pi can create an infinite loop using the `loop do...end` construct. Any code inside the loop will repeat forever. To ensure that your code is properly indented click on the Align button in the top pane to automatically align the code:

```
loop do
  use_synth :dsaw
  play :c4
  sleep 1
end
```

Click on 'Run' and you will hear the c4 note played once per second until 'Stop' is pressed. But what if we want to iterate a loop for a set number of times? Ruby has an easy way to do this:

```
2.times do
  use_synth :dsaw
  play :c4
  sleep 1
end
```

Another kind of loop is a `live_loop`. This is an infinite loop to be used when live coding a performance. Changes made to code inside of a `live_loop` don't instantly take effect rather they require the user to press 'Run' to instigate the changes the next time the loop is run. `Live_loops` enable the user to create concurrency where multiple segments of code are working together to form the backdrop of our music. The syntax for a `live_loop` is similar to a standard loop but requires a name to be given to the loop, so let's create a loop named `beat` that incorporates the `play_pattern` function that we learnt earlier. Then press 'Run' to play.

```
live_loop :beat do
  use_synth :dsaw
  play_pattern [ :c4, :g4, :d4 ]
  sleep 1
end
```

Change the `c4` note for a `f4` note and click 'Run', you should hear the note change in pitch accordingly. We can also play a pattern backwards using Ruby's handy `.reverse` function like so:

```
live_loop :beat do
  use_synth :dsaw
  play_pattern [ :c4, :g4, :d4 ].reverse
  sleep 1
end
```

As well as playing notes forward and backwards we can also play random notes using two functions:

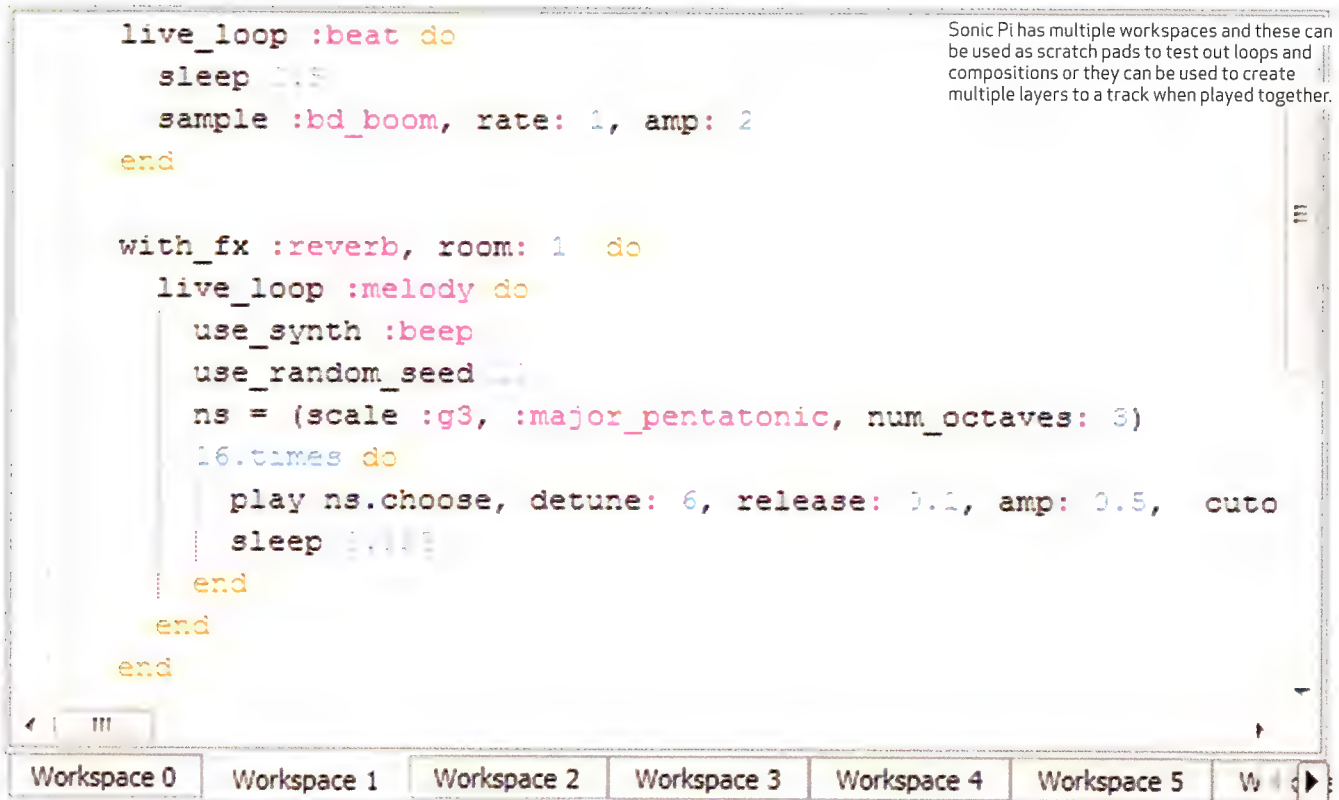
```
play rrand(50, 100)
play rrand_i(50, 100)
```

The first `rrand` can play any note between 50 and 100 including any floating point MIDI values, but the second `rrand_i` can only play integer based MIDI values between 50 and 100.

A common practice in programming is to create a function into which we can contain a block of code, then when we wish to use this code we merely call the function by its name:

```
define :loopy do
  use_bpm 480
  use_synth :dsaw
  play_pattern [ :c3, :c4, :c5, :c6 ]
  sleep 0.5
end
live_loop :testy do
  loopy
end
```

In our example, we create a function called `loopy` and use the `do...end` construct to store the code that will set the BPM to 480 beats per minute, and play a pattern using `dsaw synth`, before sleeping for half a second. Inside a `live_loop` we call the function `loopy` by its name and the code contained inside is run.



Our last Sonic Pi concept we'll introduce is samples. These are segments of audio that are pre-recorded and in the music industry they are used often to embellish a song using clips from classic songs. To use a sample in a new live_loop we'll need to recreate the following code below the existing live_loop:beat:

```
live_loop :samples do
  sample :loop_amen
  sleep sample_duration
:loop_amen
end
```

The sleep statement for this loop is unusual as it doesn't have an integer or float value visible. Rather we instruct Sonic Pi to learn the duration of the sample used and use that as the sleep value.

BUILDING OUR TUNE

Now that we have the basics under our belt let's start building our composition. Click on a blank Workspace and start your piece by creating a live_loop called beat. This will contain the code that forms the beat of our piece. Let's put a sample inside the live_loop. When completed press 'Run' to hear the beat.

```
live_loop :beat do
  sample :bd_haus
  sleep 0.5
end
```

So our beat is a sample played two times per second so that's a BPM of 120, which is quite quick and punchy. Let's build upon the beat by creating another live_loop which will contain a melody. Before we start the live_loop we will

add some FX to our audio. To do this, we'll use the fx plugin reverb to add a spacious feel to the notes. We pass the room 1 argument to instruct Sonic Pi to use the maximum-sized room available, in other words this gives the sound the maximum available spacious sound. This melody will use the synth beep for any notes played.

USING FX PLUGINS

We then add a seed to the mix which changes the starting point for any random numbers generated by Sonic Pi. Numbers generated using random are never truly random merely chaotic in nature. We used 66678 as our starting point but try other numbers to see how the composition changes. Next, we create a variable called sound and in there we store a scale of notes in the key of g3. Next, we instruct Sonic Pi to

Minecraft in the mix!

Minecraft on the Raspberry Pi has become the killer app to teach Python to classes and Sonic Pi has attained the same status for it's use of music. But what if there were a way to merge the musicality of Sonic Pi with the fun of building new worlds in Minecraft? Well, now there is and from version 2.5 of Sonic Pi you can also integrate Minecraft into your musical compositions.

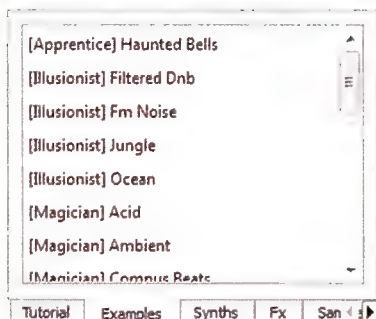
At the time of writing this is still a bleeding edge feature but there's a great deal of functionality, such as getting the position of the player or a block, changing the position of the player and block type and posting data to the chat window. The syntax

is exceptionally easy to pick up and integrates seamlessly into the standard Sonic Pi syntax structure enabling Minecraft functionality to be added to any previously written Sonic Pi compositions.

To use Sonic Pi with Minecraft just open the Minecraft application, load a world, and open Sonic Pi 2.5 and choose a Minecraft function to trigger the connection, eg the chat window:

```
mc_chat_post("Hello World")
```

Run the code and hey presto you're connected.



Haunted Bells

Created by Sam Aaron

```
live_loop :beep do
  sample :beep, rate: rand(0.125, 1.75)
  sleep rand(0.1, 0.5)
end
```

Sonic Pi comes with a few examples that you can paste into the workspaces. Try them out and learn how each of the synths, samples and FX plugins can help enhance your music projects.

Preferences

Studio Settings

☐ Invert Stereo

☐ Force Mono

Updates

☒ Check for updates

The Preferences area has everything you need to control the output of audio and various debug and editor options. There's also a log to show the output of your composition.

☒ Print output

☒ Check synth args

☒ Clear output on run

Editor

☒ Show line numbers

the note c3 with an amplitude of 0.5, putting the note into the mid-tone mix of our composition. We then wait for one second before entering into another loop that iterates eight times. But this time it plays the ambi_choir, a haunting choir sound, at standard speed but mixed down into the composition so that it appears as background noise. We then sleep for one second before closing the four loops that have been created:

```
with_fx :ixi_techno do
  live_loop :ambience do
    8.times do
      use_synth :hollow
      play :c3, amp: 0.5
      sleep 1
      8.times do
        sample :ambi_choir,
          rate: 1, amp: 0.2
        sleep 1
      end
    end
  end
end
```

Click on 'Run' to hear the composition. Does it need tweaking to match your goal? Try changing the sample playback rate from 1 to 0.5 or to 2 for different results.

So using Sonic Pi and some simple coding we have managed to create a looping piece of audio that can be recorded using the 'Record' button and uploaded to SoundCloud or used in your YouTube videos.

All of the code for this little Sonic Pi project can be accessed on our website at www.apcmag.com/magstuff. ■

Log

```
[Run 7, Time 36.5, Thread :live_loop_melody]
  synth :beep, {detune: 6, release: 0.1, amp: 0.5, cutoff
```

=> Stopping all runs...

=> Completed run 7

perform the next bank of code sixteen times, so it chooses the notes from sound variable and then uses a number of arguments to achieve the following: detunes the notes to create a slightly off sound to each note; alters the fade out and release of the note so that it fades quickly; and amp controls the level of the note played – in this case it's half the volume relative to the others. Last, we modify the cutoff to use a random note between 70 and 80 to cut off certain frequencies. We now instruct the code to wait for 0.125 seconds. Last as we have opened three loops using do we must close them correctly:

```
with_fx :reverb, room: 1 do
  live_loop :melody do
    use_synth :beep
    use_random_seed 66678
    sound = (scale :g3,
      :major_pentatonic, num_
      octaves: 3)
    16.times do
```

```
      play sound.choose,
        detune: 6, release: 0.1, amp:
        0.5, cutoff: rand(70, 80)
      sleep 0.125
    end
  end
end
```

Press 'Run' to play the composition. Remember that you can alter the random seed to produce a different sound. You can also alter the scale of notes, by changing g3 to another scale, g5, c4 etc. You can alter the major pentatonic to a minor pentatonic to produce a much darker and more sorrowful tone.

Our next live loop is used to create an ambience to the composition and, again, we shall use an FX plugin. This time it's going to be ixi_techno a low-pass filter between the minimum and maximum cutoffs. We shall call the loop ambience and first off it will perform a block of code eight times. Using the hollow synth, we shall play

The ins and outs of Android USB audio

Lollipop now includes native USB audio support for higher-quality audio. But as Darren Yates reports, there's still plenty of hope for Android 4.x devices.

Back in our June 2015 APC 'Revive Your Old Tech' superguide, we took a look at how to make your own digital audio workstation using Android devices (page 50) and external USB sound cards. To be honest, the story turned out better than we hoped, particularly given Android didn't natively support USB audio until Lollipop/5.0.

We've always been huge fans of USB audio – external audio devices connected to a computer via USB – particularly on the PC, simply because it takes the sensitive audio circuitry away from the interference commonly generated by CPUs and most digital components to give you cleaner, higher-quality audio.

But with the introduction of native USB audio support in Lollipop, interest in mobile USB audio is starting to grow – and not just for playback.

USB AUDIO RECORDING

Over the last ten years or so, there's been a boom in high-quality portable digital audio recording devices. Brands like Zoom and Tascam are churning out models that record at up to 96kHz/24-bit stereo for under \$300. Meanwhile, smartphones, with considerably more horsepower to play with, are typically stuck offering recording from a single built-in MEMS (micro electromechanical system) microphone somewhere in the corner of the chassis.

The beauty of USB audio recording is that it takes away the actual recording box as the arbiter of quality and leaves it in the hands of the USB audio capture device. The recording box simply becomes a digital stream recorder, which is a much simpler task.

We might live in a digital world, but audio recording is still very much an analog endeavour and depends on the process of converting real-world analog audio into digital samples. It has to start with low-noise, low-distortion microphones capturing the changes in air pressure that represent sound as an analog signal. You then

need low-noise, low distortion preamplifiers to increase the amplitude of the analog signal so that it's at a useable level. Finally, you need high-quality, fast analog-to-digital converters (ADCs) to convert that analog signal into some digital format. Without those analog components, ADCs are useless.

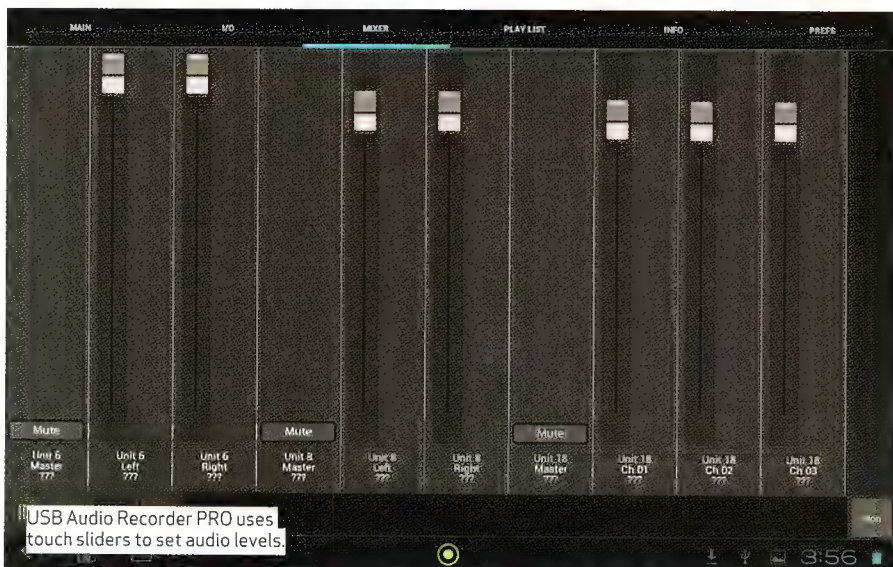
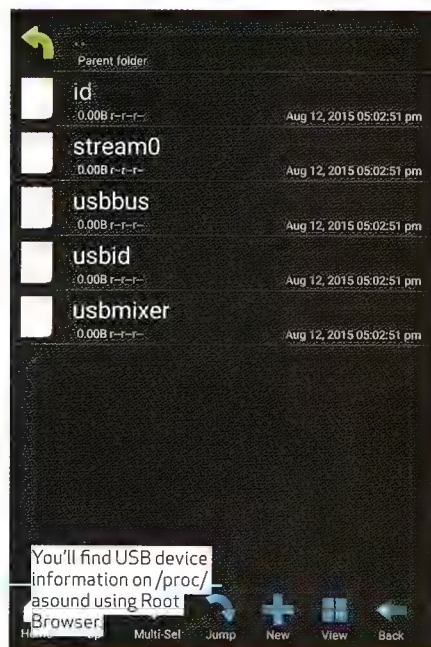
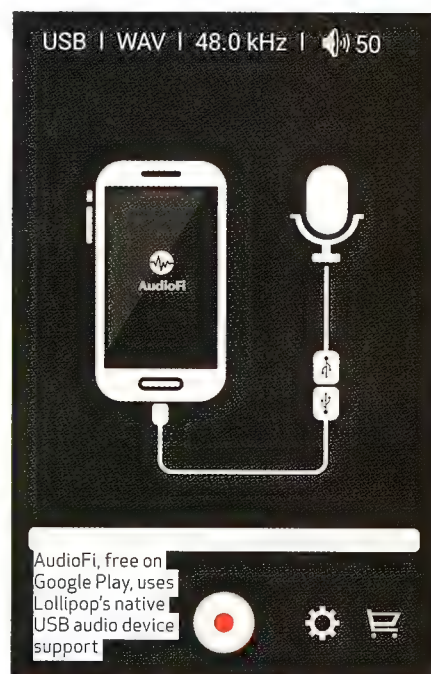
USE AUDIO PLAYBACK

Not surprisingly, getting high-quality audio playback is the reverse – starting with accurate digital-to-analog converters (DACs) to turn the digital stream back into an analog approximation; then low-noise, low-distortion preamplifiers or power amplifiers to feed the output to a sound system or headphones, respectively.

The key to much of this conversion process (recording especially) is 'low noise' – doing this within the confines of a smartphone or tablet, where you have much more going on besides, is not easy.

NO LO LILLOPP?

But if you're still using a KitKat/4.4 or older device, USB audio definitely isn't out of the question. The thing Google did with Lollipop/5.0 is provide native support, so it's built into the basic OS.





The Blue Snowball USB mic is claimed to work with USB Audio Recorder Pro.

That doesn't stop you adding it yourself to older devices. The key is searching for apps that incorporate their own USB audio device driver software. In that situation, you only need a USB-OTG or USB Host port and at least Ice Cream Sandwich/4.0 (although there are reports it may work going as far back as Honeycomb/3.1). Ultimately, it's a 'your mileage may vary' scenario.

OUR TESTS

To see how this all works in practice, we ran tests on a number of low-cost DACs we purchased online, looking at how they perform with Lollipop/5.x, as well as older Android releases.

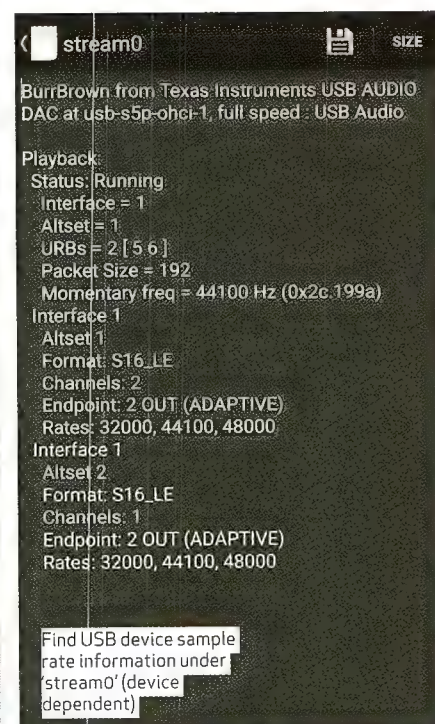
DACS - BURR-BROWN PCM2704C

One of the biggest names in the audio business for several decades has been

US chipmaker Burr-Brown (BB). Like almost all successful brands, BB began life in a garage, grew quickly and, now years later, still cranks out audiophile-quality tech (its OPA-series of low-noise, low-distortion audio op-amps, for example, are legendary). About a decade ago, BB was taken over by US giant Texas Instruments (TI) and today, churns out CD-quality USB DACs, one of the earliest models still available being the PCM2704C.

It's been superseded these days but the Windows 7-certified PCM2704C is still available by the truckload online and has excellent references with 98dB signal-to-noise ratio (SNR) and total harmonic distortion (THD) as low as 0.006% when used at line-level. With a typical 32-ohm headphone load, that THD rises to around 0.025%, which still

isn't bad. If the PCM2704C has any perceived downside, it'll be that it only supports up to 48kHz/16-bit samples rates, which is low by today's 192kHz/24-bit peaks. However, it still matches most music audio formats and more importantly, 48kHz/16-bit is generally as high as Android's compressed audio codec support goes, so unless you're playing PCM samples, anything more is mostly a waste (developer.android.com/guide/appendix/media-formats.html). The chip's power consumption is between 23 and 35 milliamps (23-35mA).





This USB audio module offers single-channel line-level recording for under \$10.



Unless you have a Type-A host port, you'll need a USB-OTG cable for USB audio.



USB DAC for \$1.50? This C-Media CM108AH is everywhere on eBay.



Our \$15 PCM2704C DAC provides headphone, optical and coax S/PDIF output.



This is the DAC inside the popular MUSE X5, but you can find it in many no-name clones, either as a bare board or in a small aluminum chassis. Unlike the X5 and its clones, the one shown here not only has a 3.5mm headphone/line-out port, it also features S/PDIF coaxial and optical outputs. It cost us \$15 on eBay with the aluminium chassis – you could save \$5 and go for the bare board, but the chassis is as tough as teak. Either way, it's arguably the cheapest way to get S/PDIF audio out of an Android device.

In fact, we had no trouble getting this one to work on our Lollipop/5.1 ROM'd Samsung Galaxy S3 with all apps – it connects straight in via a USB OTG cable. It also worked nicely on our Acer Iconia Tab A200 with Android 4.0/ICS through eXtream's USB Audio Recorder PRO app from Google Play (which comes with its own USB audio device drivers).

The low-power consumption also means you shouldn't have any trouble bus-powering it via USB-OTG.

MAXIMISING BATTERY LIFE

That said, clearly anything you plug into your Android device that's bus-powered is going to draw its power from your device's battery, lowering battery life. So to maximise that battery life, flick your Android device into airplane mode while recording. Not only will it turn off all radio communications (improving audio quality), it should also help ensure you get no interruptions or dropouts during recording. And as with PC recording, don't try to play games or do other demanding tasks at the same time – for the same reasons.

GENERIC USB AUDIO #1

Just to show how easy it is to get caught up in trendy jargon, call something a 'USB DAC' and it will cost more than a 'USB sound card', despite the fact the two are ostensibly the same thing. Search on eBay and you'll find the later

by the truckload, starting for as little as \$1.23 for this tiny USB dongle – and that includes shipping! The DAC in this one is just a blob on the circuit board we've identified as a C-Media CM108AH, rated by the company as having a 94dB SNR and 0.03% THD with a 32-ohm load. It also includes a single (mono) 16-bit microphone input.

Again, this one worked perfectly on all our Android devices, including the Lollipop'd Galaxy S3. In practice, we found the SNR of our test unit closer to 70dB and the power consumption around 30mA. One thing to keep in mind, chip specs don't necessarily always translate into real-world performance – you still need good physical layout design to ensure you're not introducing interference nasties into the audio path. But I prefer this module to my PC's integrated motherboard audio, and by a long way.

Break the headphone socket of your Android device? This is one very low-cost way to still get audio from it, but ultimately, you get what you pay for (more or less).

GENERIC USB AUDIO #2

But just to show that not everything always goes according to plan in APC Labs, the second one we purchased cost us \$7, but included basic on-board switchable EQ, volume control as well as separate microphone and line-in ports. Lollipop had no trouble finding this one – it even provided full control of Android audio apps via the on-device buttons, operating audio levels, play/stop and next/previous track control. The only problem is, it didn't output anything. On a Windows PC, it works perfectly and even more surprisingly, USB Audio Recorder PRO on the same device quite happily recognises it, connects to it and plays perfectly. The other disappointing thing was that the line-input isn't stereo – it's only mono (single-channel). Still, for converting old audiobook tapes into digital, combine this with USB Audio Recorder

PRO, plug in your cassette player and it should do the job nicely.

We ripped the cover off this one and again, it features another blob for a chip, but we assume it isn't a C-Media CM108AH, given it worked intermittently with Android. Power consumption was also around the 30mA mark.

LEGACY USB DAC'S

We talked last time about our success with Creative Labs' old Sound Blaster Extigy and Audigy 2 NX devices. Both

of these devices provide line-level stereo input with an SNR approaching 90dB and they work well, but only via USB Audio Recorder PRO. By the same token, Creative's Sound Blaster Play dongle happily worked via USB Audio Recorder PRO and natively on Lollipop.

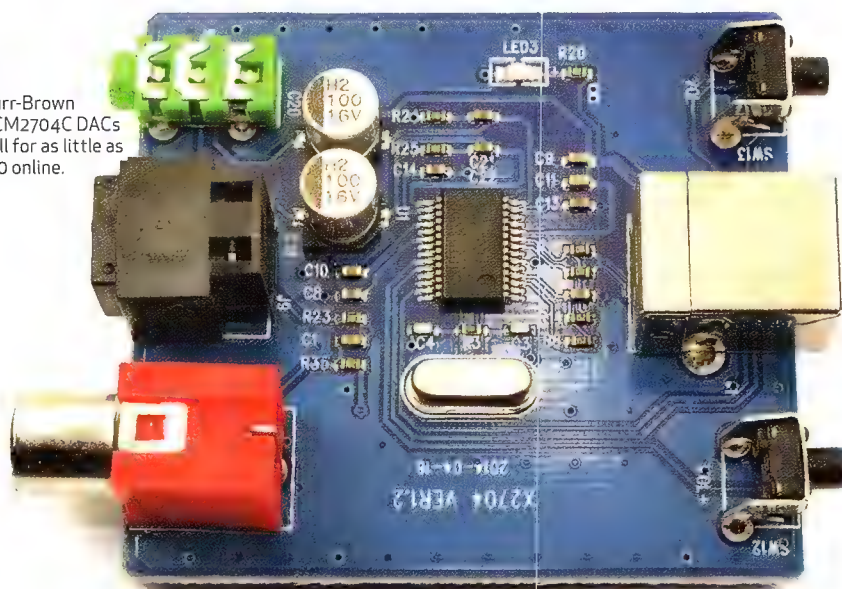
But USB Audio Recorder PRO works with a large range of more modern audio interfaces, including Behringer's UCA202/UCA222. And if you need studio-quality microphone recording, a number of balanced-XLR microphone interface devices are also supported, including Lexicon's Alpha/Lambda/Omega series, plus M-Audio's M-Track mic/MIDI combo unit. You can also use dedicated USB microphones such as Samson's Go Mic Direct and Blue's cute little Snowball. There's an extensive (but not exhaustive) compatibility list for USB Audio Recorder PRO at www.tinyurl.com/p8nxqyr.

Two other things. First, make sure you plug in your USB audio device before you launch the USB Audio Recorder PRO app; otherwise, the device won't be detected and won't work. Second, the app isn't guaranteed to work with every device, so grab the demo, available as a sideload from eXtream — www.audio-evolution.com/downloads/USBAudioRecorderPROtrial_1.4.0.apk.

SETTING AUDIO LEVELS

One of the best features of USB Audio Recorder PRO is its mixing console that lets you control inputs and outputs using linear/slider controls. It works extremely well, if somewhat inconsistently — depending on the device, you'll find you can move some stereo channels as a locked pair, but in other devices, they'll be separate right/left channels, making it difficult to keep both tracking when you change levels. But the eXtream team has cleverly incorporated the peak-program meter (PPM) display into the mixing console, so you can monitor

Burr-Brown PCM2704C DACs sell for as little as \$10 online.



recording levels as you would with a genuine digital audio recorder.

DIGITAL AUDIO WORKSTATIONS

Then there's the question of once you get the audio into your Android device, what do you do with it? Apple was brilliant to get GarageBand onto the iPad, making it the default tool for a generation of aspiring musicians. But Android isn't devoid of such tools with options like n-Track Studio Pro and Audio Evolution Mobile Studio (from the makers of USB Audio Recorder) that enable you to mix multiple channels of audio, turning your device into a portable digital audio workstation.

Audio Evolution Mobile Studio features eXtream's own USB device drivers, so it works on (almost) anything from Android 4.0 up, while n-Track Studio Pro also has its own USB compatibility list (tinyurl.com/ppa7lyo) and installs on a minimum of Android 2.3.

LOCATING USB DEVICE SPECS

Android is a highly modified version of Linux — but still, it's built around Linux, so you can peer into your device OS and find out what's going on. Head to Google Play and install Root Browser — it's a file manager that delves down a bit deeper than most, but is free and doesn't need root access.

Android lists or 'enumerates' all devices connected to the OS through the 'proc' virtual filesystem, including USB audio devices starting with Lollipop/5.0. Make sure your USB sound module is connected to your Android device and launch Root Browser. Tap the little 'home' icon at top-left, scroll down, choose the 'proc' folder and now scroll down again until you find 'asound'. Once this folder opens, you'll likely find two subfolders — 'card0' and 'card1'. We can't guarantee it but 'card0' is usually your device's internal sound module and 'card1' will be the USB device. Now depending on how your version of Android enumerates things, you'll see a series of files. Open them as 'text files' with your favourite text editor and you can read the data. For example, 'stream0' in our case provides details on the current run status and specs of our PCM2704C DAC with info on available sample rates.

IMPROVEMENTS

It might seem as though only the audiophile brigade would be interested in the benefits of USB audio, but with many of us throwing down hundreds of dollars on high-end headphones, there's already demand for high-end USB audio products. Adding native USB audio support to Android will only grow that further. ■

Behringer's UCA222 is also supported by USB Audio Recorder PRO.



Make a simple Arduino MP3 audio player

Forget your iPod – make your own MP3 audio player. Darren Yates shows you how using Arduino and an audio shield.

Microcontrollers are changing the world. The ability to write your own software code, flash it to a chip and have that chip control almost anything is changing the world. It's enabling anyone to make almost anything and Arduino shines bright. This month, we'll turn an Arduino into a simple MP3 player using an audio codec shield.

VS1053 MP3 SHIELD

Audio for Arduino is difficult (it was never designed for it), but made much easier by the VS1053 MP3 shield, an extension board featuring VLSI's VS1053 multi-codec audio chip.

Read the specs (you'll find them at www.vlsi.fi/en/products/vs1053.html) and this is one versatile chip – it plays Ogg Vorbis, MP3, AAC, WMA and WAV audio straight off the bat, and with a software patch, it'll even play lossless FLAC audio as well. The VS1053 shield board is even better – it combines MicroSD card storage (up to 32GB) and also takes advantage of the VS1053's audio recording capabilities (16-bit WAV/PCM or Ogg Vorbis via patch) through a built-in microphone or your own via the 3.5mm mic input.

Delving into the specs further shows the chip can drive a standard 32-ohm headphone load. Total harmonic distortion (THD) is a reasonable 0.05% at that load and signal-to-noise ratio (SNR) at full-scale is 94dB – not earth-shattering, but still very respectable.

You'll find the 'VS1053 MP3 Shield' on eBay for as little as US\$13.

HOW IT WORKS

Look at the block diagram and the heart of the VS1053 is a DSP – digital signal processor – with its own RAM, control inputs, stereo analog-to-digital converter (ADC) for recording, stereo digital-to-analog converter (DAC) for playback and built-in headphone driver.

All we need is to write code that gets



our Arduino board to act as traffic controller and transfer audio data from the MicroSD card to the VS1053 chip and playing out through the headphone socket (the outer of the two).

WARNING: BATTERIES HEADPHONES ONLY

However, there is one drawback with that headphone socket – and it's a bit technical – so the short version is the chip's output has a DC offset, which means you can't plug it straight into an audio amplifier. If you do, the VS1053 chip will likely blow up. However, the solution is to use a number of DC-blocking capacitors. The addendum PDF at www.vlsi.fi/fileadmin/app_notes/vs10XXan_output.pdf shows

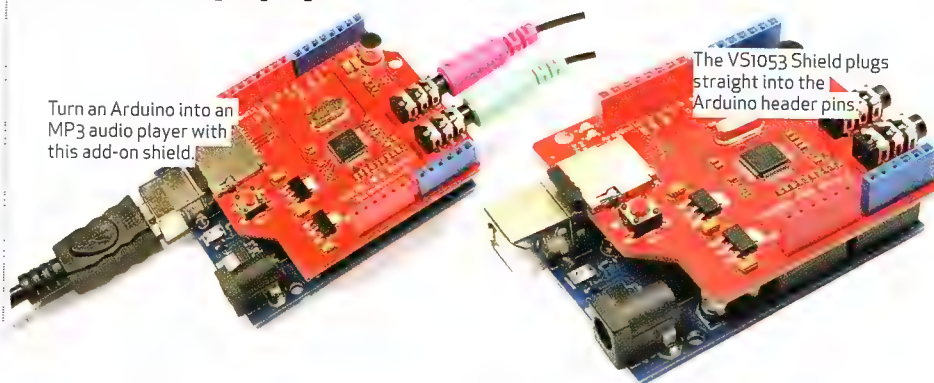


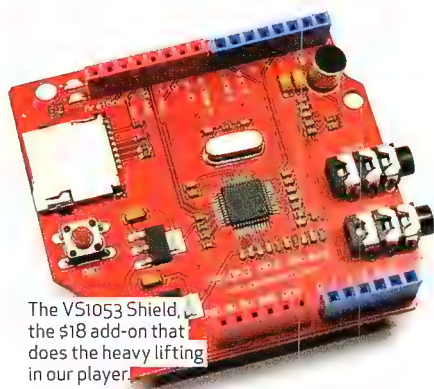
you the circuit required. Otherwise, we recommend you stick to headphones only and power it with a USB battery power pack (for safety, don't use a USB wall charger). Power draw is about 80mA, so you should get a genuine full day's playback from a 2200mAh USB power pack.

VS1053 ARDUINO LIBRARY

That's the hardware side of things; now for the software. For that, two special Arduino code libraries – SdFat and SFEMP3Shield – do much of the work for us. The SdFat library takes care of initialising the link between the Arduino microcontroller chip and the MicroSD card, setting its speed (4MHz). The library only supports FAT filesystem, so make sure you format the MicroSD card to FAT32 before using it here.

The SFEMP3Shield library handles most of the goodies inside the VS1053 chip. By the look of it, it doesn't do everything (recording, for instance, seems to be missing), but there are still





The VS1053 Shield, the \$18 add-on that does the heavy lifting in our player.

plenty of toys to play with, including support for VU meters, graphic equalisation, even changing the speed of playback.

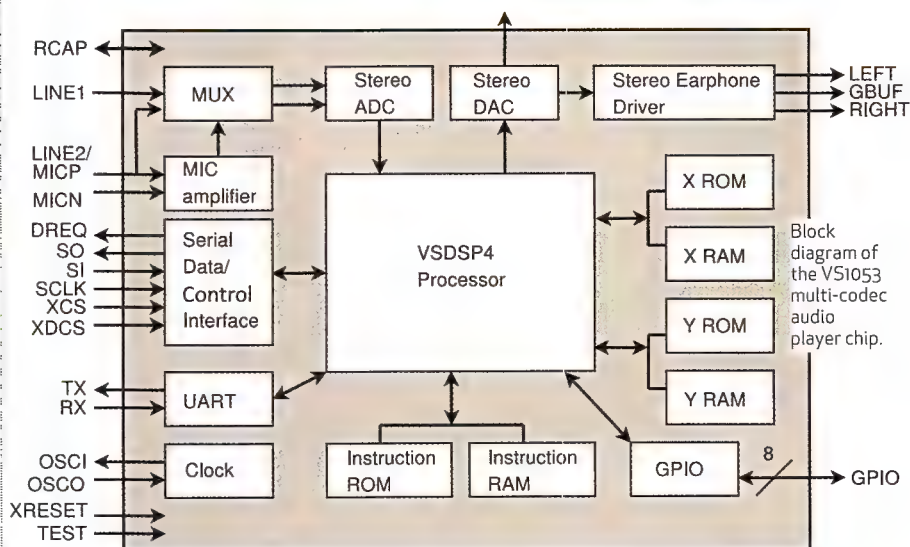
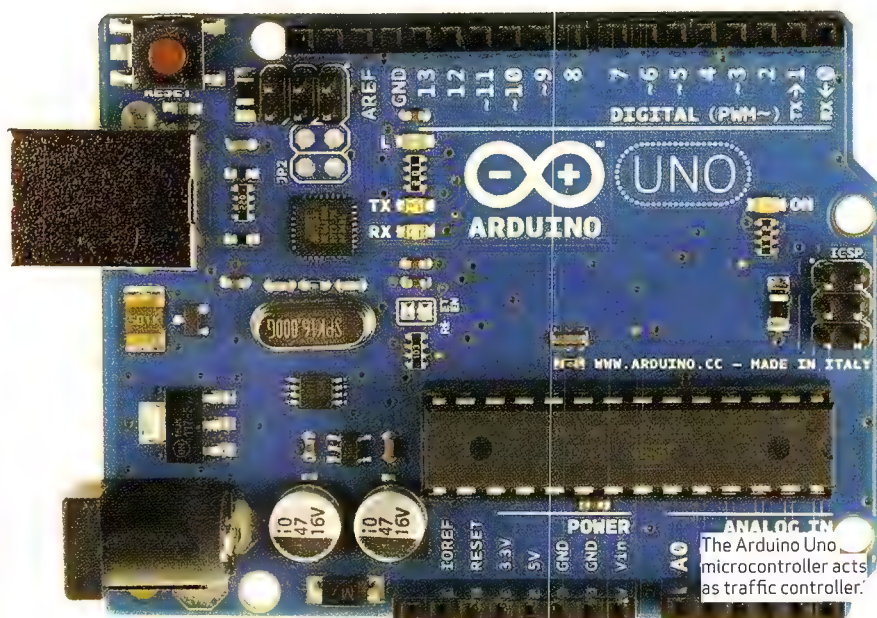
Much like the Arduino's ATMEGA328P microcontroller chip, the VS1053 is programmed using a series of registers, each housing a number of controls or 'bits' that can either be read from or written to, controlling the various functions inside. The SFEMP3Shield library provides us with the shortcuts to coding those individual register bits, allowing us to use more recognisable 'plain-English' statements in our Arduino code.

HOW OUR MP3 PLAYER WORKS

To get things rolling, we've used both libraries to make a very simple MP3 player with just a few lines of code. It's so simple, it has no buttons – it automatically begins playing MP3 tracks it finds on the MicroSD card out through the stereo headphone socket as soon as you apply power. Those tracks can be up to 48kHz sample rate, 16-bit depth, mono or stereo and up to 320Kbps bit rate.

The one limitation needed to make this player as simple as possible, however, is that MP3 tracknames must be 'track000.mp3', 'track001.mp3' and so on – up to 255. (We're using a built-in library function called 'playTrack', which takes a single 8-bit integer to count/select the tracks).

As soon as power is applied, the player begins with the 'isPlaying' flag set to zero – this triggers code to increment the 8-bit counter from -1 to 0 and uses the counter to fire the MP3Play.playTrack() command, looking for 'track000.mp3' (count 0) on the MicroSD card. If it finds the file, it begins playing and the 'isPlaying' flag is set to 1. When the track is finished, 'isPlaying' goes back to zero, which increments the count again and the next track played (count 1, 'track001.mp3'). Once the last track stops playing, the counter increments again and the playTrack() goes looking for the next track. But with no tracks remaining, the playTrack() command,



which has been returning a value of '0' to the 'returnVal' variable each time, now returns an error-indicating non-zero value. This triggers our code to reset the counter to zero and tells the playTrack() command to play the corresponding file ('track000.mp3'), creating a very simple 'repeat-all' loop.

SETTING AUDIO OUTPUT LEVEL

We've noted it in the source code, but the statement for setting audio output levels works back-to-front from what you might expect – the library code we're using expects to see an 8-bit integer with '0' for maximum output and '255' for silence. Each increment apparently represents a 0.5dB fall in output level, but we're not convinced – still, we've set it to a nominal '40'. Be warned though – setting it to '0' will drive your low-ohm headphones hard and loud!

Get the code!

Download the code for this project from our website at apcmag.com/magstuff. Unzip it, go into the 'Sparkfun-MP3' folder, copy the 'SdFat' and 'SFEMP3Shield' subfolders into the /libraries subfolder of your Arduino IDE install. Restart the IDE if it's already running. Load up the AB11_mp3player.ino code, flash it to your Arduino board, remove the power, install the VS1053 shield with MP3 tracks on a MicroSD card, plug in your headphones, plug the USB power pack in and you should be away.

Don't have the Arduino IDE? Get the latest version from arduino.cc/download.

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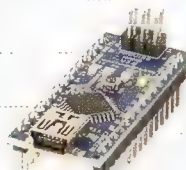
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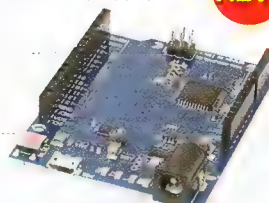
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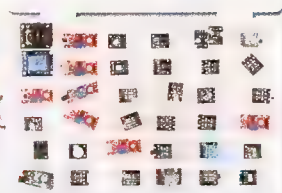
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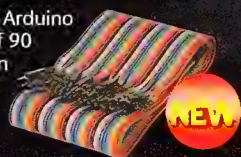
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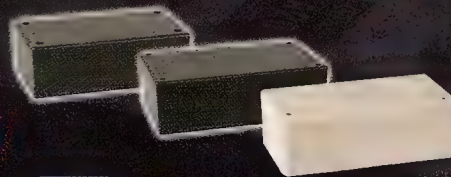
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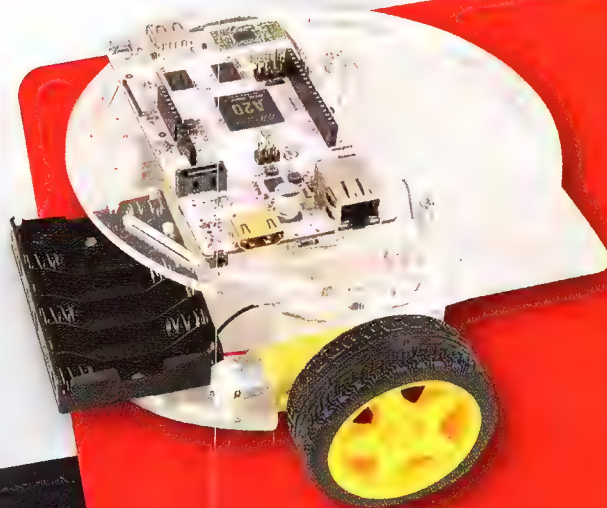
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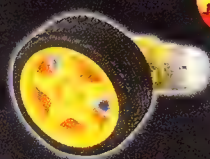
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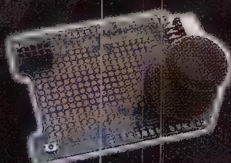
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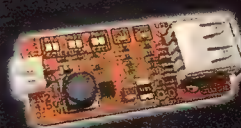


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Part 13: Code your own Java games continued

This month, Darren Yates continues his look at game development with a simple WWII air combat arcade game incorporating collision detection and object oriented programming.

You could easily argue game development is the hardest kind of programming to succeed at, simply because the results are so subjective – if gamers don't like your game, that's pretty much the end of it. But it is also a heap of fun and a fast way to learn various aspects of coding. In the last few months, we've looked at concepts as diverse as object-oriented programming (OOP) and collision detection. Yet combine the two and it actually makes game development – on a very simple level at least – much easier to do.

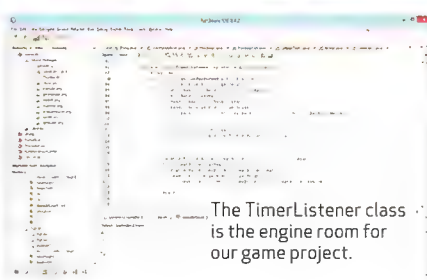
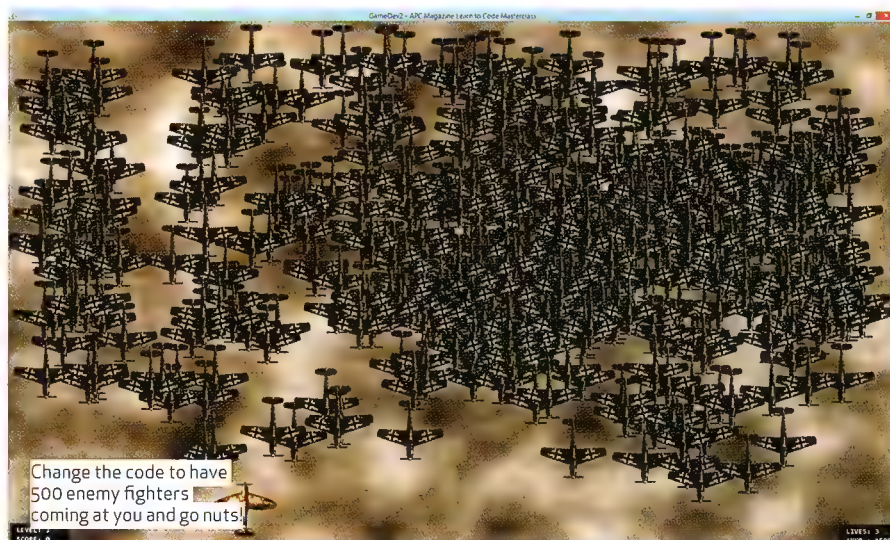
GAME DESIGN BEFORE CODING

In any software design project, actual writing of code should be one of the last things you do – and it's especially true of gaming. Sure, you should keep an 'agile' mindset and allow room for brilliant ideas to pop up. But really, you have to sit down and scope out your game play first. You could call it 'system analysis', but here, we'll just call it 'what on earth are we doing in this game?' In creating our modded game of 'JPong' from last month, we learned how to do basic collision detection – checking if one virtual object has collided into another – but also how easily we could replace a black background with a cloudscape and the JPong balls with numerous World War II-era Spitfire aircraft.

Following on from that theme, our abridged gameplay analysis for this month is that we're going to build a very simple WWII fighter arcade game that's part 1942 and part *Space Invaders*. The source code is about 300 lines of code (tiny as games go) and the whole thing about 230KB compiled. It might be simple, but it still has many of the basics you'll find in much larger games.

BASIC GAMEPLAY

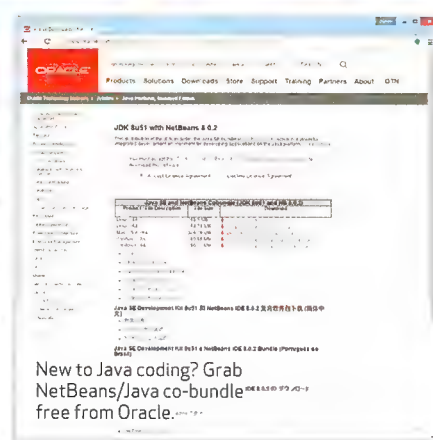
The way we've designed this game is that the player will operate a brand-new state-of-the-art Spitfire Mk.88 fighter with newly swept-back wings. Using the right and left arrow keyboard keys, the fighter will sweep



side-to-side at the base of the game window and fire ammunition with the Control key. To give it some passing resemblance to real life, you'll be able to fire at will (not just one bullet on the screen at a time as with *Space Invaders*) but you'll also have a limited amount of ammunition. So the basic gameplay is essentially this – shoot down all of the enemy fighters before you run out of ammo. If you don't, you lose a life. Three lives gone and it's game over.

THE ENEMY

Enemy flyers will be piloting the equally-new Messerschmitt Me888 but to keep our code size manageable for the moment, they don't shoot back – their job is to just avoid your fire and run the player out of ammo. There'll be 20 enemy fighters to face, however, being only made out of cardboard, these planes need only

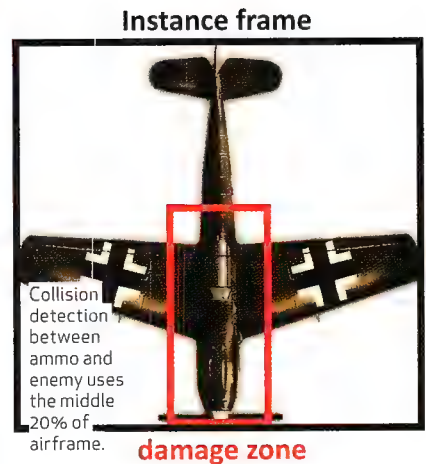
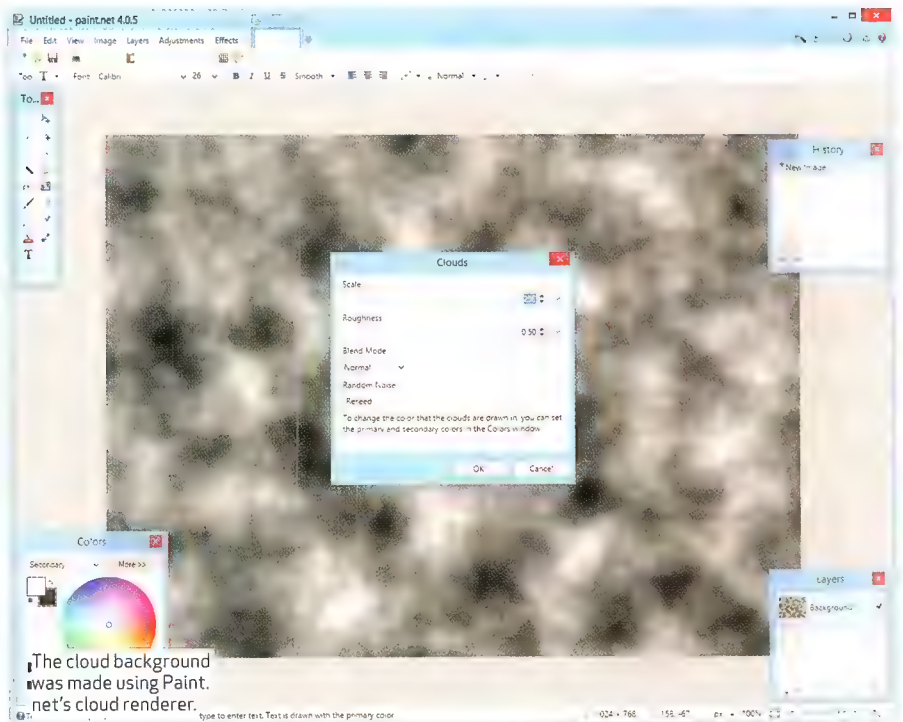


one shot in the centre-fifth of the aircraft and it's flame-outs and 'neeeeyyaaarrrr-plonk!'

OOOPS!

It might not sound like much, but there's still plenty for us to code. For starters, we have to monitor the movement of up to 20 (or possibly more!) enemy aircraft, plus our player fighter. We have to keep track of ammo levels and, more importantly, monitor and track every bullet to see if it hits an enemy aircraft. In terms of code, that's more than enough to start with!

What we've just done is a very rudimentary analysis of how our game



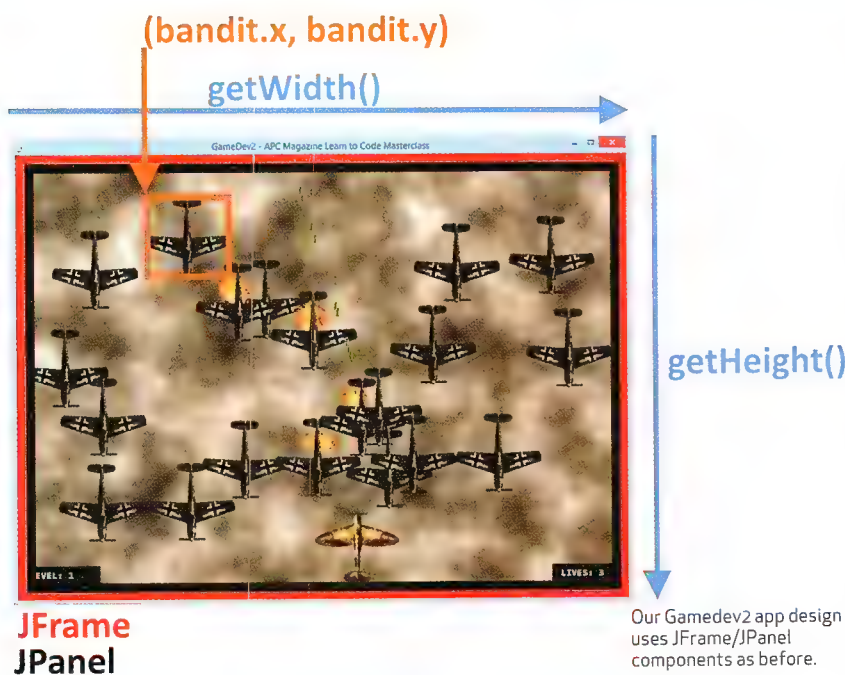
track of. Our Fighter will only have one instance (the single player), but it still has important parameters – for starters, it's position. If it's moving across the bottom of the screen like *Space Invaders*, we need to know it's X- and Y-axis coordinates, even though the Y-coordinate is fixed. We need to know its velocity (the speed at which it moves), its ammunition capacity, the number of lives remaining.

The enemy fighters or 'bandits' constitute a separate class because they have additional parameters (technically, we could have made the home fighter and enemy fighters all from a base class called 'Aeroplane', but we haven't quite got to covering the topic of interfaces just yet).

Unlike our fighter, bandits can move in both the X- and Y-axes, so we need their position, but we also need to give them an initial movement vector, which means we need to know the rate of movement in each axis of each plane (we'll call these 'dx' and 'dy'). Remember, we want the enemy fighters to move independently around the screen. In practice, we're going to do this the same way we bounced the JPong balls last month – we're aiming for simple here, just to get the concepts across, but there's no reason you couldn't crank things up yourself!

Now for the FighterBullets. Each bullet fired by the fighter has to be monitored – not just for collision detection with an enemy aircraft, but also when it goes beyond the play screen or 'map'. So again, our bullet class needs position and movement attributes. You can see this in the source code.

Our classes also need methods that control what the class instances do – for example, our fighter, the enemy fighters and the fired bullets all need to be moved. The bullets need to be tracked and we need to know if an enemy fighter has been shot down. These are all handled with in-class methods.



will work, the limits of its features (scope) and roughly how it will play. When you're implementing OOP principles, one of the early steps is to look at your analysis and work out what are the objects you want to keep track of. So far, we've got our fighter, up to 20 enemy aircraft and our fighter's ammunition. This last one might seem weird, but bullets are objects, too – each bullet will have its own path, but as we said before, we need to monitor the movement of each bullet to know whether or not it's hit something.

That means for the moment, we need three classes – 'Fighter', 'Bandit' and 'FighterBullet'. Classes are normally

represented visually using what's called a UML (Unified Modelling Language) diagram – we've created one for the Fighter class to give you an idea. Basically, it's attributes first, followed by the methods of the class. Remember, a class is a template from which, we can make any number of copies or 'instances' – that should give you a hint about how we create multiple enemy fighters and the Spitfire ammo.

CLASS ATTRIBUTES, METHODS

Next, we need to nail down the parameters or 'attributes' of each class – the details that we need to keep

FRAME, PANEL AND MAP

But for our classes to be worth anything, we need a frame and a panel for them to be displayed on. The basic GameDev2 class creates a resizable JFrame that's initially 1,024 x 768-pixels and on that JFrame, we create a JPanel instance called 'Map'. It's on this map object that we'll draw our game.

FRAME RATE

From one perspective, all we're doing is creating a fancy user-driven animation. You might remember from last month, we talked about how fast you need game frames to be drawn in order to see smooth movement. Depending on the game, you can go as low as 30 frames per second and still get a reasonable result, but we're going for better than 'reasonable', so we'll set the rate for a nominal 50fps.

But what does that actually mean in practice? If you think of video, a 30fps playback rate means frames are displayed at 30 per second, or once every 33.33 milliseconds. For our game to run at 50fps, we need to update the movement of bullets, enemy fighters and our hero once every 20 milliseconds (1/50th of a second). So essentially, we need to divvy up the processes into 20 millisecond segments – and for that, we'll bring in the Swing Timer class (Java has two timer classes – we're using the Swing GUI timer because it works better with GUI apps). The Swing Timer class allows you to create a timed delay, after which, an ActionListener class is called to execute whatever code you want to run. The thing with the Timer class is that it keeps firing after each delay setting, so all we need to do is set the delay to 20 milliseconds and we get our ActionListener code call firing off as required.

The key now is to ensure we do everything we need to do – move the fighter based on the user keyboard controls, move all of the enemy fighters and any bullets in play, check the bullets' movement and do collision checks, check that all fighters remain within the Map panel/frame and adjust the movement as necessary – and do it all within 20 milliseconds. If it takes longer, the frame rate will either slow or movement will be jittery as the code struggles to keep the pace. But really, we have just 20 enemy fighters to play with and even on my old 3GHz Intel Sandy Bridge Core i5-2300 PC, I can crank up the number of enemy fighters to 5,000 and it still works just fine.

FLAMEOUTS

When an enemy fighter has been hit correctly by a bullet (middle 20% of the fighter frame), we have to do something to make it look like it's been

Fighter

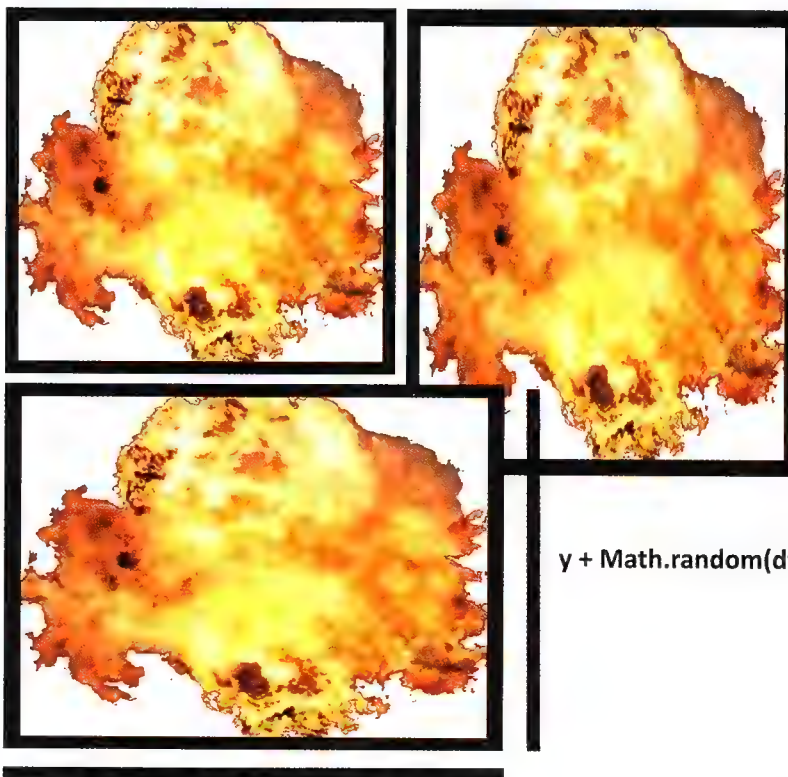
UML diagram for the Fighter class in our game project.

x: integer
y: integer
dx: integer
baseWidth: integer
baseHeight: integer
score: integer
bullets: integer
shutdown: integer
level: integer
lives: integer
explodeCount: integer

attributes

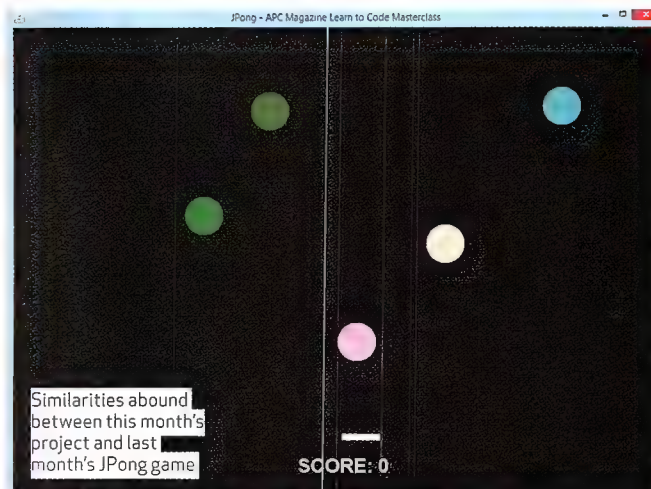
Fighter()
Fighter(x: integer, y: integer)
move(width: integer, height: integer)

methods



$x + \text{Math.random}(dx)$

The simplest way to create flame flicker is two-direct random size changes.



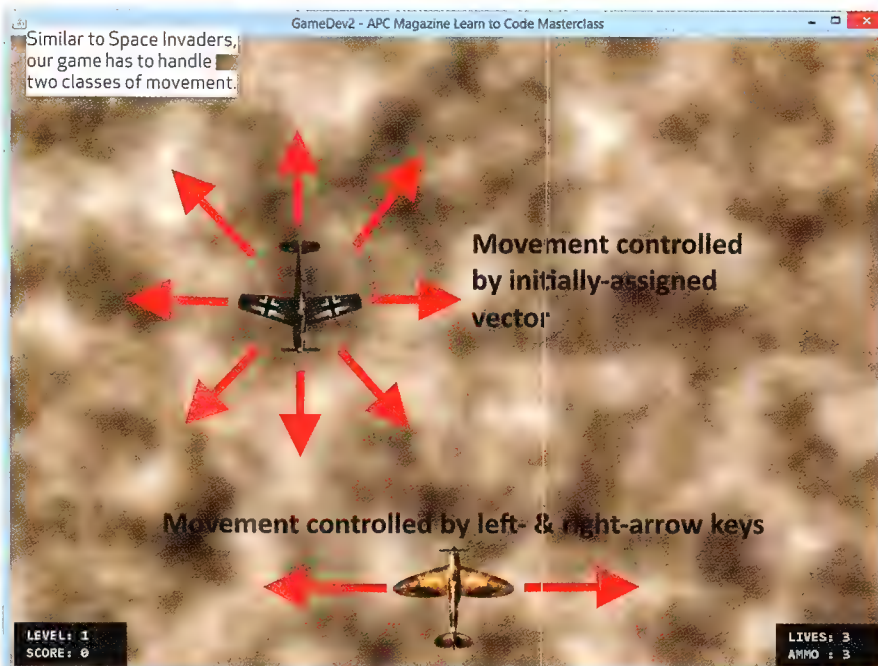
hit, so the simplest way we came up with is to have a flame ball flickering behind the cockpit. Each 'instance' of Bandit class has an 'explodeCount' attribute with the value of 50. When an enemy fighter is hit, the 'shotdown' flag is set and each 20 millisecond frame, we display a fireball PNG image just behind the central fuselage of the aircraft. To make it flicker, we add in the `Math.random()` code to vary the size of the PNG as it's displayed. Do this every 20 milliseconds and you get a flameout-like flicker. The 'explosionCount' integer is decremented every timer delay period, which gives a total of one second (or thereabouts, given the Swing GUI Timer isn't perfectly accurate).

TIMERLISTENER ACTIONPERFORMED

This little method is the engine room of the game code – it runs every timer period and controls the movement and display of everything that goes on. It implements the `fighter.move()` method to update the player's positioning of the fighter and also uses a new coding toy called 'Iterator'.

An iterator is an object for travelling through an `ArrayList` of objects. Right at the top of our code, we create an `ArrayList` of 'bandits' (enemy fighters) – here, we use the `Iterator` object as a means of incrementing our way through that `ArrayList`: while ever we haven't reached the end of the list (that is, iterator 'iBandit' has a 'next' object in the array), we perform the `bandit.move()` method on each one.

We do the same thing for each bullet – we start with an `ArrayList` of `FighterBullets` and use an iterator to move through the list to update the position of each one and note its location. It's also at this point that we check to see if it's hit anything. We also check to see if the position of the bullet has gone off the map (meaning it's hit nothing). If so, we remove it from the `ArrayList` – this way, we only have



to concern ourselves with the bullets 'in play'.

PLAY WITH IT!

As simple as this code is, it's impossible for us to cover everything that's going on – hopefully, if you've been following this series, you'll be picking up things in the code we've covered before and seeing how we've used them here. Either way, get stuck in and muck

around with it – change the code, change parameters, swap lines, even delete lines, see what happens. Don't be frightened to make the code crash – learn why it crashed. We're certainly not claiming our game project this month is the be-all of quality code, but coding is very much like learning the piano or guitar – no-one ever learned to play a music instrument by just looking at it!

Get the code!

Download the code for this project from the APC website at www.apcmag.com/magstuff. Unzip the zip file and you'll find a second zip file – don't unzip this second one.

Grab the NetBeans IDE + Java JDK bundle from Oracle. Once installed, open NetBeans, select 'File > Import Project > From ZIP', choose the second zip file and all of the project components should install. Run the source code and the game should appear on your screen. ■

downtime

» GAMES EDITOR TROY COLEMAN



FREE | PC, PS4 | WWW.PLANETSIDE2.COM

PlanetSide 2

Choose your side in the biggest cross-platform war.

An old Yoda adage comes to mind off the back of tens of hours spent blazing a trail through the battlefields of this massively multiplayer online shooter: "You must unlearn what you have learned." It may very well be viewed from a familiar first-person perspective, and it does involve firing lead into other combatants through the medium of pulling triggers, but with its dizzying scope and ceaseless three-way war, *PlanetSide 2* will force you to rethink the way you play.

For anyone jumping into either the PS4 or PC version, it's an initially rough process. The fact that each of the four unfathomably large continents to shoot up are filled with upwards of a thousand players at any one time means you have to get used to feeling fairly incapable if you approach this as you would a traditional team-based

multiplayer shooter. Very quickly you learn to think strategically, assessing the fortifications of an enemy outpost before committing yourself to a cause. If there are a hundred foes and just the one of you... well, you don't need be a statistician to figure out that the odds of you making a dent are somewhere between 'dead' and 'really dead'.

Running around on your lonesome with nary a care for your force's actual objectives is just not the way things work in *PlanetSide 2*. Matches literally never end, so the only real way to measure your effectiveness satisfactorily is by working at those objectives until your screen fills with a victory or a defeat graphic, and the whole thing starts all over again.

It's very easy to join up with a squad on the fly, thanks to the social management menus on offer. While we played, there was healthy use of the

excellent proximity chat function. Swipe up on the PS4's touch pad and you'll switch between squad chat and the natterings of everyone nearby. The latter of these is particularly inspired, as it offers a sense of camaraderie: you're playing alongside people who know they rely on one another to function in this endless fight. (We encountered next to none of the vitriol we've sadly come to expect in other shooters.) Allies alongside you shout out warnings of snipers perched in rocky outcrops, and you can even find yourself joining up with waves of babbling players, swapping war stories as they rush to the next enemy fortification. Friendly fire is a thing though, so there's a little too much breathing room for legitimate trolls to pop up every now and then.

Not everyone will make it to these impressively social areas of the game, as the shooting is sluggish

compared to *CoD* and *Battlefield*, and the visuals are muggy (perhaps a knock-on effect of the grand scale). But in terms of pure layout and gameplay design, the outposts, tech plants and military stations you fight over are perfectly tuned to handle billowing armies, with just enough cover in the right places to ensure there are always options for a milling force to choose from.

Given the spectacle, the niggles are minor, and here we have a shooter unlike any other on console. Turn up your most rousing of background soundtracks and join the charge.

■ Matthew Sakuraoka-Gilman

Verdict

The grand scale makes this as fresh and as different a shooter as you could ask for.



"It sounds complicated, but like its looks, N++ stays minimalist by teaching you the rules of each element gradually."

You can change the visual filter on the fly, from the retina-scorching 'Heat' to the rather more calming 'Evening'.

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RECOMMENDS

\$29.95 | PS4 | WWW.NPLUSPLUS.ORG

N++

Minimalist art style, maximum ninja.

The first 125 levels in this deceptively demanding platformer are grouped into a chapter called 'Intro'. That should offer an indication as to how short each one is, how many there are in total, and how much training you'll need to succeed.

The aim is simple: reach the glowing gate within 90 seconds by sprinting, sliding, wall-jumping, and collecting time-increasing gold. That's easier said than done, given portals that shoot you out the other side with amplified speed (enter from above and they'll blast you into the floor, forcefully separating your ninja's limbs), a clone machine that spawns a new you based on your movements five seconds prior (since colliding with a clone means death, you become your own worst enemy), and numerous springs, bounce pads, and switches. And then there's the dangerous stuff. The use

of mines is particularly interesting: sometimes you'll pass through a sea of dormant ones that wake on contact, then need to return, having to make sure to take a different path around those you activated. Elsewhere are homing rockets, laser turrets, barging robots, and gauss cannons, all of which mean instant death.

It sounds complicated, but like its looks, N++ stays minimalist by teaching you the rules of each element gradually. Some stages are still frustrating – like having to make pixel-perfect jumps through electrified drones as missiles give chase – but you can instantly restart levels or else skip them entirely.

Multiplayer-wise there's Race, in which players compete to reach the exit first. However the level isn't over when one person wins, as others can beat them by collecting more gold and not dying. Players use the environment to kill passively

rather than actively attacking each other – eg setting off explosives for pursuers, or baiting the crosshairs of a laser onto a competitor.

Better is Co-op though, as unlike Race, it makes players interact with each other rather than merely occupy the same space. Its strength lies in puzzles that work as well for two people as three and four. Some are symmetrical, where each must synchronise their skills across separate but identical routes. Others might require one player to take a low road through a string of undulating obstacles, for instance, while the other takes the high. And as only one ninja needs to reach the exit, sometimes you'll have to lock yourself in with a turret, or suicide dive into a sea of explosives, to trigger a switch to open the door. It's about coordination, timing, and sacrifice.

Finally, there's a stage creator that expands an

already 2,360-strong library. Our crowning glory is a huge spiral maze filled with clone machines that spill out more and more ninjas as we pass, dozens of our past selves chasing each other like some existential nightmare.

It's a solid addition, and the ability to download community-made levels means there's plenty of life left even once you've completed the base game.

With a stark art style that looks ripped from a BBC Micro, N++'s cold, uninviting procession of puzzles sometimes makes it feel like one of those training exercises they give to apes, but there's no denying the clever design at the heart of it.

■ Ben Griffin

Verdict

Pure and punishing, under its cold exterior N++ bursts with seriously clever and creative challenges.



Ah, such a happy moment before everyone is brutally murdered.

apc
RECOMMENDS

"While well-performed and far from unlikeable, you're meant to enjoy seeing this lot die."

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Until Dawn

This interactive movie's a schlocky horror picture show.

For years, and to varying degrees of success, videogames have doggedly pursued the cinematic. But from the basically broken *Dragon's Lair* to the tonally flabbergasted *Fahrenheit*, these interactive movies have, largely been a bit crap. That is, until... now.

Until Dawn is about eight friends who return to a mountain cabin after the mysterious death of twins there a year prior. What starts as part anniversary, part sexy holiday soon takes a turn into, "Aaaargh! Get away, get away, noooooo!" territory as a psycho stalks them across the Washington wilderness and murders them one by one. Or not, as the case may be.

See, *Until Dawn* understands the importance of choice, and as such, how you play determines who survives. It puts you in the driving seat rather than the baby booster, making you feel like your actions matter by introducing a crucial fear of failure. Supermassive calls choices 'butterfly effects', but instead of flapping wings causing hurricanes, initial results seem like light gusts.

Near the start, for instance, you're led to a shooting range where you can target bottles and sandbags with a bolt-action rifle. Choose to headshot the friendly little squirrel chilling out on a picnic bench and nature addresses the balance by sending a crow to claw your face, which leaves a bloody mark there for the rest of the game. Other outcomes are even less visible. Early on, when ditzy prom queen Jessica tumbles down a mine shaft, big bro on campus Mike can either jump down to help her or call out instructions — either way, the section plays out the same. Whether it's climbing a cliff or rebooting a generator, you only seem to halt the train rather than divert it.

In the third act, however, earlier actions do pay off. For a less spoilery example, after booting an aggressive wolf in the jaw it'll see you as the Alpha and back down in the next encounter. Magnified mistakes soon mean you can die a grisly death (and I do mean grisly), locking entire plot chunks and character arcs off for your playthrough in a shower of viscera.

That's why *Until Dawn* is a

mere five hours long and lets you freely access each of its ten episodes, complete with recaps to remind you of any narrative shifts. This open approach means it's easy to sample different story threads without fuss, though a dialogue-skip option would have been handy.

For this reason, you should think of *Until Dawn* from the perspective of the viewer rather than the character. There's a layer between the cast and the player. These characters are story-serving archetypes in an intentionally schlocky narrative. They're a group of clearly late twenty-somethings cast as teenagers who use words such as, "psyched," and "OMG!" to express glee at their parents being away. While well-performed and far from unlikeable, you're meant to enjoy seeing this lot die.

Supermassive nails a tone which is enjoyably creepy and samples from a broad palette of horror influences from *Scream* and *Saw* to *Scooby-Doo* (at one point a character genuinely screams, "It's a g-g-g-ghoost!"). Unlike, say, the organic horror of *Alien: Isolation* or *Condemned*,

here it's scripted and often involves an assortment of wildlife or prank-pulling mates providing cheap jump scares.

There isn't much exploring or puzzling to speak of, with such challenges as finding a key to open a door among the mind-bogglers, but what saves *Until Dawn* from feeling formulaic are absolutely extraordinary visuals amplified by masterful framing and camera work. Creeping through a darkened hallway, torchlight casting shadows along walls, is exciting even if you know there's little chance of anything truly surprising happening.

So as far as movie-like game experiences go, *Until Dawn* is a tightly plotted, well performed popcorn munching success. It's simple, yes, but hugely entertaining while it lasts.

■ Phil Iwaniuk

Verdict

A confident argument for interactive film. A starry cast, gorgeous visuals and great performance capture.





We've put in 60 hours and still haven't seen everything. Heavensward is intimidatingly massive.

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HOT PRODUCT



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Final Fantasy XIV: Heavensward

Meeting sky high expectations.

The real test of a good MMO is in how convincing its world feels. In how it creates a vast sense of place, in how its inhabitants feel like they actually live there. After all, once the story is over and you've 'finished' it, it's the quality of the setting that'll keep you coming back.

Eorzea had transformed itself into a land well worth visiting even before this expansion, but instead of falling short like so many have in the past (hello *World of Warcraft's* Mists Of Pandaria), *Heavensward* exceeds expectations. It brings nine new zones to *A Realm Reborn*, each one far bigger than anything that came before it. With so many different areas to explore, from the gothic city of Ishgard to the spectacular, winged tower of Zenith, when diving in it truly feels like you've entered a completely fresh frontier.

The main storyline guides you through each new environment, picking up directly after where *A Realm Reborn* left off.

It's a bit of a slow start, but things quickly pick up as you make unexpected alliances

in your attempt to broker peace for the wyvern-besieged city. Soon you'll find yourself just as hooked as you would be by any grand tale in the *Final Fantasy* series. The return to fetch quests can feel like a step backwards at times, but it's no deal breaker. This is a new adventure after all, and you'll be getting yourself embroiled in epic eight-man Primal fights soon enough.

Speaking of which, encountering the towering, insect-like samurai Ravanna for the first time is an especially dramatic moment. After an epic battle with a new ally (we won't spoil who), it's then your turn to face him. With his four swirling blades and room-filling attacks, it's a seriously challenging fight – and it's also a great example of the tweaks *Heavensward* has made to keep its fisticuffs fresh. To complement this, all of the main classes have also been given an overhaul. *Heavensward* sees the level cap jump from 50 to 60, and with that rise comes a host of new skills. Each one adds something a little different to the way you play. Monks, for instance, rely on chaining moves together to 'stack'

their offensive strength, but this often gets broken during lulls in long battles, so they can lose power. However, now they have new moves to compensate for that downtime, allowing them to maintain their charge, or loose it all at once with a devastating strike. It's an incredibly useful addition for those that like punching things, but other classes don't fair quite as well. Bards in particular are feeling stung, as their attack output hasn't been raised at the same rate as the rest.

There are also three new classes to try, falling into the classic MMO triangle of defensive, offensive, and healing. While each one helps to bring variety to older party line-ups, the tanky Dark Knight is the clear favourite, and with good reason. With their huge two-handed swords and impressive, moody skillset, playing as one will make you feel like an absolute badass. The Astrologian is also a hit, with the card-drawing mechanic adding a satisfying layer of risk alongside their traditional healing magics. However the offensive Machinist falls a little flat by comparison.

While managing their gun turrets is extremely satisfying, the ammunition-juggling mechanic has some noticeable balance issues. Much like the Bard, the new skills here just don't seem to slot together quite as neatly as they should.

With 60+ hours of content, the base game is a fine thing in itself, and makes a great introduction for those who've never played an MMO before. And with such a welcoming community, absorbing yourself into its world is a pleasure even if you decide not to invest in the new areas.

Balancing issues are forgivable, and while *Heavensward* does require a sizable time investment, it's well worth it. The storyline is sufficiently gripping that it's not shamed by the rest of the *Final Fantasy* series, and its world is so rich that sightseers will exhaust themselves before they exhaust it.

■ Daniella Lucas

Verdict

Fine-tuning issues aside, this is a huge new chapter for FFXIV, both in its story and map expansion.





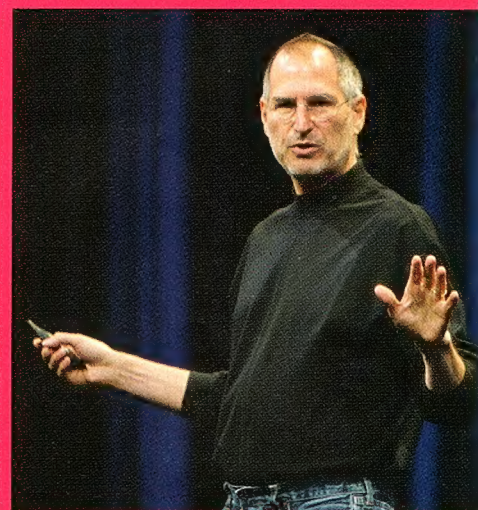
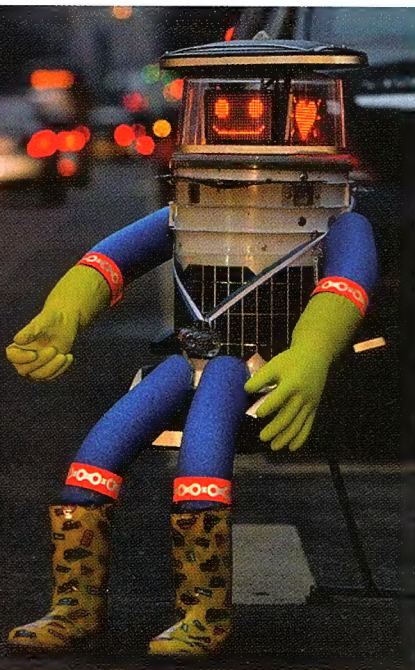
KFC to launch literal 'photo bucket' in Canada

Because a picture's worth a thousand original recipe pieces.

To celebrate six decades of serving chicken-related products to Canadians, KFC has teased the arrival of a Bluetooth-enabled chicken bucket that prints photos taken by your smartphone, ensuring that your cluckin' good times will be captured forever. The Polaroid-style photos appear from a hidden compartment at the base of what KFC has dubbed the 'Memories Bucket'. This isn't the first time that KFC has dipped its beak into Bluetooth technology — KFCs in Germany recently gave their customers tray liners that doubled as paper-thin keyboards, allowing them to keep their phones and tablets free of chicken grease while tweeting out a few zingers.

WHO KILLED HITCHBOT? AND WILL THE GOOD CITIZENS OF PHILADELPHIA BE ABLE TO REASSEMBLE HIM?

It's hard to believe that anyone would want to cause harm to HitchBOT, the loveable Canadian robot that has been on a mission to hitchhike across various parts of Europe and North America since last year. Unfortunately, that's exactly what some mindless neanderthal has done, putting an end to the cheerful robotic chap's journey in Philadelphia. But is it really the end? Local Philadelphian makers and hackers, led by the Hacktory's Georgia Guthrie, have offered to help repair HitchBOT, stating that they wish to "let everyone, especially the Robot community, know that Philly isn't so bad." HitchBOT's creators have yet to respond.



Steve Jobs musical coming in 2017

EXPECT A BETTER VERSION OF THE MUSICAL IN 2018.

After having stood on stage and played maestro to crowds of enthusiastic tech fans over the years, it seems oddly fitting that an opera be made about the life of the late, great tech innovator, Steve Jobs. *The (R)evolution of Steve Jobs* is set to open in Los Angeles in 2017 and will focus on many of the well-documented events of Jobs' life, including his relationship with his estranged daughter, Lisa, as well as his private life with wife Laurene Powell-Jobs. Composer Mason Bates will be helping the project, which will begin its workshop phase in September.



Australian team wins robot soccer world championship

AUSTRALIA BEATS GERMANY 3-1

While Australia is yet to win a FIFA World Cup, we can at least claim to be the back-to-back winners of the Robocup SPL World Championship, thanks to a stunning 3-1 win over Germany in early August. The championship, which involves AI-controlled autonomous robots, pits two teams of five against each other, with only their software to guide them. The robots used are identical in terms of hardware, so it's up to the each country's software engineers to come up with the most advanced artificial intelligence in order to play better. Now, Australia is looking to make it a hat-trick at next year's championships. ■

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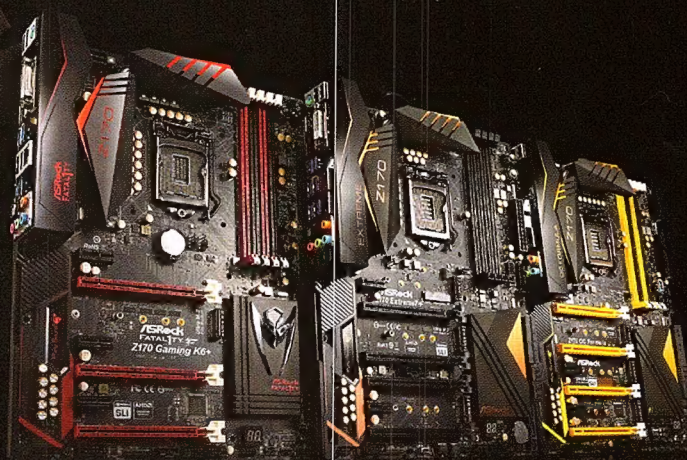
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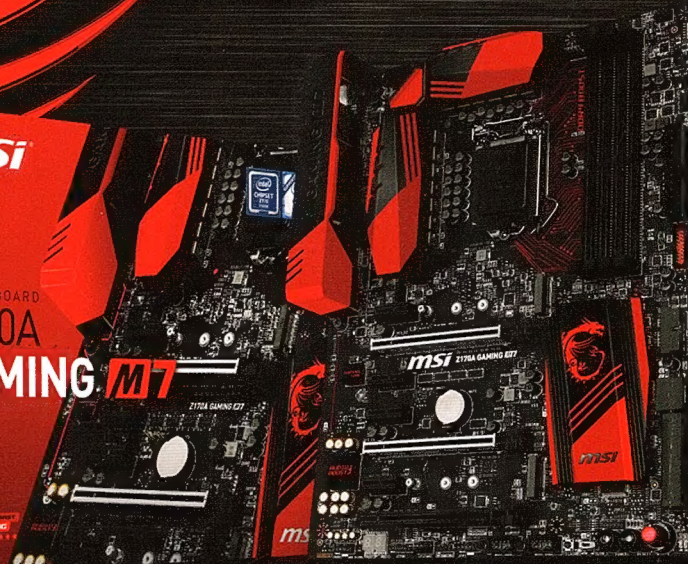
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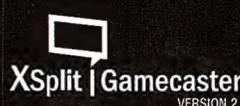
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07 3420 3200 computeralliance.com.au
07 3387 1500 gamedude.com.au
07 3369 3928 umart.com.au
07 4779 8054 digitalmatrixcomputers.com.au

SA

Allneeds Computers
08 8211 8661 www.allneeds.com.au

TAS

Taspro Computers
03 6424 1911 taspro.com.au



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